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This is an extension of the Star Catalogue presented in Publication No. 1 of the Vassar College Observatory, which gave a catalogue of stars within one degree of the North Pole, whereas the present publication extends the catalogue to two degrees from the North Pole. Both catalogues are based upon photographs taken by Professor Donner, of Helsingfors, Finland, a series of twelve negatives being under consideration, which together include all the stars of less than two degrees polar distance. The present paper treats first of the measurement and reduction of 89-degree plates, with a preliminary catalogue of the stars found thereon; second, of the inter-adjustment of the several plates and their combination with the former catalogue; and third, of the formation of the final catalogue of all the stars found on twelve plates.

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A principal inquiry in the above paper is to determine the position both of the galaxy itself and of the planes toward which the stars appear to crowd, irrespective of the existence of the galaxy. Some previous inquiries might appear to show that the tendency to crowd toward the galaxy is well marked even in the case of stars visible to the naked eye, but the present investigation shows that this tendency is less marked when the galactic stars are considered as forming a collection separate from the others.

No. 72. Newcomb, Simon, assisted by Frank E. Ross. *Investigation of Inequalities in the Motion of the Moon Produced by the Action of the Planets.* Quarto, viii+160 pages. Published 1907. Price $1.00.

The principal object of the above work was the hope of explaining by gravitational theory the observed variations in the mean longitude of the moon, shown by more than two centuries of observations to exist, but not yet satisfactorily accounted for. The work naturally divides itself into four parts. One of these treats of the theory of the subject, including under this head not only the general equations, but the numerical details on which all the computations are based. In this part the fundamental quantities are reduced to products of two factors, one of which depends upon the coordinates of the planet; the other upon the geocentric coordinates of the moon. The first factors, termed planetary, are numerically developed in Part II. This development falls into two parts, one treating the direct action of the planet, the other the indirect action through the sun. In Part III is found the numerical development of the factors depending upon the moon alone, and of the partial derivatives as to the lunar elements. In Part IV are presented the combinations of these two factors and the final results of the work.

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No. 138. Adams, Walter S., assisted by Jennie B. Lasby. *An Investigation of the Rotation Period of the Sun by Spectroscopic Methods.* Quarto, iii+132 pages, 2 plates, 5 text figures. Published 1911. Price $3.00.

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No. 93. Hale, George E., and Philip Fox. *The Rotation Period of the Sun, as Determined by the Motion of the Calcium Flocculi.* Octavo, 54 pages, 2 plates, 5 text figures. Published 1908. Price $0.40.

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No. 235. Hale, George E. *Ten Years' Work of a Mountain Observatory: A Brief Account of the Mount Wilson Solar Observatory.* 12mo, 99 pages, 65 text figures. Published 1915. Price, in paper cover, 50 cents; in cloth, 75 cents.

This little book has been written to meet a demand for information regarding the purpose and work of the Mount Wilson Solar Observatory. As it is intended for the general reader, untechnical language has been used and numerous illustrations have been provided. The purpose of the Observatory is to throw as much light as possible on the evolution of stars and stellar systems. Its researches naturally fall into three chief divisions, comprising:

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The book describes typical methods of work, involving the invention, design, and construction of new telescopes and other instruments, their erection on Mount Wilson in Southern California, their use in photographing celestial phenomena, and the study and interpretation of the photographs in the offices and laboratories in Pasadena.

No. 115. Boss, Lewis. *Preliminary General Catalogue of 6,188 Stars for the Epoch 1900.* Quarto, xxxvii+345 pages. Published 1910. Price $7.00. (Out of print.)

No. 115. Reprint of the above. Published 1915. Price $3.50.

This volume contains the results of a comprehensive and thorough discussion as to the positions for 1900, proper-motions, and other useful particulars in relation to all stars in both hemispheres that are visible to the naked eye. About 2,000 stars fainter than the sixth magnitude are also included, because they are among the stars which have been most precisely and frequently observed in the past. The primary object of this work was to employ substantially all useful evidence of

observation in determination of proper-motions with a high degree of precision, especially in the systematic sense. Results of researches leading up to the present work have been published in Volume XXVIII of the Astronomical Journal. Therein are described the steps by which the results of the various original catalogues of observed star-positions are made systematically consistent—one with another, and with a resulting normal system. These and subsequent labors in preparation of the present work have led to various useful results, additional to those concerning the main issue—computation of systematically accurate proper-motions. Thus, the present work contains very carefully computed positions of all the stars suitable to be classed as standard stars. The systematic errors of observation due to magnitude-equations of the respective observers have been eliminated from the right-ascensions of the catalogue with substantial success. In the catalogue is incorporated a Normal Uranometry prepared by Dr. S. C. Chandler. This is founded upon all the most important measurements and estimates of brightness, rendered homogeneous by the application of systematic corrections for color and position in the sky. Three appendices contain respectively:

Appendix I. Ephemerides of Polar Stars.
Appendix II. Notes to the Catalogue, Periodic Proper-Motion, etc.
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No. 119. Perrine, Charles D. *Determination of the Solar Parallax from Photographs of Eros made with the Crossley Reflector of the Lick Observatory.* Quarto, v+98 pages, 1 plate, 2 text figures. Published 1911. Price $2.50.

This publication gives a detailed account of observations and computations made in deriving the solar parallax from photographs of the minor planet Eros taken by means of the Crossley reflecting telescope of the Lick Observatory during the interval October 1900 to January 1901. The value of the parallax deduced is 8.8067″±0.0025″.

No. 147. Russell, Henry Norris. *Determinations of Stellar Parallax,* based upon Photographs taken at the Cambridge Observatory by Arthur R. Hinks and the writer; with Magnitudes and Spectra determined at the Harvard College Observatory under the direction of Prof. E. C. Pickering. Quarto, vi+142 pages. Published 1911. Price $2.00.

This work is based on 254 plates of 37 different fields, taken with the Sheepshanks *equatoréal coudé* of 12 inches aperture and 20 feet focal length. The relative parallaxes of 52 stars especially selected for observation, and of 242 others chosen as objects of comparison, have been determined. Every precaution was taken to eliminate systematic error; and the discussion of the results for the comparison-stars indicate that the residual errors—whether depending upon a star's position, magnitude, or spectral type, or on the season of the year at which observations were made—can not exceed a few thousandths of a second of arc. As regards accidental errors, the results appear also to be of high precision. The conditions suitable for obtaining the most accurate results for a given amount of work expended are next discussed, and, later, the astrophysical conclusions derivable from the data for the principal stars. Detailed tables of the numerical results of observation conclude the volume.

No. 43. Peters, C. H. F. *Heliographic Positions of Sun-Spots, Observed at Hamilton College from 1860 to 1870.* Edited for publication by Edwin B. Frost. Quarto, xiii+189 pages. Published 1907. Price $2.50

The book contains the series of visual observations of the sun made by Professor Peters in the decade beginning 1860. They in effect continue the routine observations of the sun begun by Carrington in 1853 and ending in March 1861. The tables give the position of each spot referred to the center of the disk, the deduced heliographic latitude, the longitude from the node, and the heliographic longitude. For each day on which Peters observed, the angular distance between the prime meridians of the systems of Carrington and Peters is given.

No. 86. PETERS, C. H. F., and E. B. KNOBEL. *Ptolemy's Catalogue of Stars. A Revision of the Almagest.* Quarto, III+207 pages. Published 1915. Price $3.50.

The Catalogue of Stars, made by Hipparchus, transmitted by Ptolemy, and commonly called Ptolemy's Almagest, is the first and most ancient known manuscript which gives a description of the heavens of sufficient exactness to admit of comparison with modern observations. For many centuries it was practically the only record of positions of the stars which the world possessed, and it has accordingly been a subject of many researches and investigations.

About 1876-77, Dr. C. H. F. Peters, of Hamilton College, realizing the importance of verifying the exactitude of the Catalogue, begun the studies which led up to the present volume, calculating, from modern observations, the longitudes and latitudes of all of Ptolemy's stars, embracing every probable star near Ptolemy's positions, corrected as far as possible for proper-motion.

At almost the same time when Dr. Peters began his labors, Mr. Edward Ball Knobel, of the Royal Astronomical Society of London, took up this work on nearly the same lines, and for a considerable time the two continued their labors quite unknown to each other; but being fortunately brought into communication, a plan of cooperation in the enterprise was agreed upon. Before any progress was effected, however, Dr. Peters died, in 1890. But his executors placed his manuscripts and notes at the disposal of Mr. Knobel, who completed the work embodied in the present publication.

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This table furnishes the smallest divisor of every number up to the limit 10017000. The multiples of 2, 3, 5, and 7 are not listed as being easily obtainable from inspection. At the same time the failure to find a given number in the table is evidence that it is a multiple of one of these numbers. The omission of such numbers greatly reduces the bulk of the tables and adds very slightly to the complexity of the arrangement.

A list of smallest divisors really serves to find all of the divisors of a number, for one may divide out the smallest factor as listed in the table and then proceed to obtain the smallest divisor of the resulting quotient. This process may be continued until a quotient is obtained which is a prime.

Factor tables for the first nine millions have already been published, but are for the most part unobtainable. The tables herewith published have been compared, entry for entry, with the previously printed tables and what is believed to be a complete list of errors is also given in the Introduction. The tenth million has been checked against a table in manuscript by Kulik deposited in the Vienna Academy of Sciences. Comparison with all of these tables has been made five times (six for the first three millions). The tables were printed by photographic methods which are believed to eliminate many errors which commonly occur by the falling out or breaking off of types.

The problem of finding the factors of a given number is important in itself and is constantly met with in the theory of numbers and in the theory of groups. The allied problem of finding the number of primes between given limits makes a reliable list of primes of the first consequence. This list can now be made as far as the first ten millions, it is believed, with absolute confidence. Computations of the number of primes in the successive millions, and indeed in shorter intervals, tally exactly with the counts made from these tables as far as these counts have been made.

No. 165. LEHMER, DERRICK N. *List of Prime Numbers from 1 to 10006721.* Folio, XVI+133 pages. Published 1914. Price $5.00.

Until the completion of the author's Factor Table for the first ten million numbers the construction of a reliable list of primes was impossible, owing to the numerous errors still undetected in the old tables of factors. The list of primes herewith published is taken from the corrected tables of factors and has been checked by comparison with the results of the count of primes made independently of factor tables by Meissel and Bertelsen. The number of primes in each successive thousand as counted by Glaisher has also been compared with the number obtained from the list. The results indicate a very high degree of accuracy for the list.

The successive primes are arranged in columns of one hundred, there being fifty columns to the page. Each page thus serves to list five thousand primes. The total number of pages is 133, and therefore the total number of primes listed is 665,000. The page is identical in size with the page of the Factor Table. The arrangement enables one to tell at a glance the rank of any particular prime and the number of primes between any two given limits.

No. 78. Shaw, James Byrnie. *Synopsis of Linear Associative Algebra: A Report on its Natural Development and the Results Reached up to the Present Time.* Quarto, 145 pages. Published 1907. Price $1.50.

This synopsis aims to present in a synthetic way the results, up to the date of publication, of various methods of studying linearly distributive and associative operation. The abstract theory of such operations is the intent of the book. Under this head are included matrices, linear substitutions, bilinear forms, vector algebras, quaternions, and the general theory of operations. The main results of numerous memoirs on these subjects are put into organic relationship and some further results are deduced.

No. 120. Decker, Floyd F. *The Symmetric Function Tables of the Fifteenthic.* Quarto, 21 pages. Published 1910. Price $1.25.

This publication presents the table of symmetric functions of the equation of the fifteenth degree. Similar tables of equations of lower degrees have previously been published, references to which are given, together with a list of corrections of misprints found in some of them. The use of the tables is exhibited by the solution of a numerical equation and by the calculation of a resultant of two equations.

The publication contains also a historical sketch, compiled from original sources, of the formulas connected with the calculation of symmetric function tables, which may not only give an appreciation of the development of the subject, but which will be useful in calculating tables of higher orders.

No. 161. Moulton, F. R., in collaboration with Daniel Buchanan, Thomas Buck, Frank L. Griffin, William R. Longley, and William D. MacMillan. *Periodic Orbits.* Quarto. In press.

A large part, though not all, of the periodic orbits treated in this book belong to the problem of three bodies. The first chapter contains certain theorems on implicit functions, the solutions of analytic differential equations, and a new treatment of linear homogeneous and non-homogeneous differential equations having periodic coefficients. The second contains a treatment of elliptic motion by the methods which have more general application. This is the simplest astronomical problem in periodic orbits. Certain additional methods are illustrated in the third chapter on the spherical pendulum, with new developments of certain elliptic functions. The fourth chapter treats of periodic motion about an oblate spheroid with applications to the motion of Jupiter's fifth satellite. The fifth chapter is devoted to a complete discussion of oscillating satellites in both two and three dimensions, in the case in which two of the bodies are finite and moving in circles, while the third is infinitesimal, and in which the centers of libration are collinear with the finite masses. Chapter VI is a treatment of the same problem by another method having important advantages in certain cases. Chapter VII is a discussion of the problem when the finite bodies move in elliptical orbits. Chapter VIII is a generalization of Lagrange's collinear solutions of the problem of three bodies to the general case of n bodies. Chapter IX is that of Chapter V for the equilateral triangular points of libration. Chapter X treats of the motion in the case in which two masses are equal, the third infinitesimal or finite, and the three always occupying the vertices of an equilateral triangle. Chapter XI treats of satellites and inferior planets with application to the lunar theory. Chapter XII treats of superior planets. The problem of Chapter XIII is similar to that of Chapter XI, except that there are four or more bodies. Chapter XIV treats of the orbits of many small masses revolving around one large one. In all cases the existence of the periodic solutions is proved, methods of practically constructing them are given, and numerical illustrations are often added.

No. 151. Stager, Henry W. *A Sylow Factor Table of the First Twelve Thousand Numbers, giving the possible number of Sylow sub-groups of a group of given order between the limits of 0 and 12000.* Folio. 132 pages. In press.

The main purpose of this table is to furnish direct information as to the possible number of sub-groups of a given order under Sylow's Theorem, "If p^a is the highest power of a prime, p, which divides the order of a group, G, the number of sub-groups, H, of order p^a is congruent to unity, modulo p." These sub-groups of order p^a are called Sylow sub-groups. Each number is expressed as the product of powers of primes, and for each prime factor greater than 2 the values of k, other than zero, of all divisors of the number of the form $p\ (kp+1)$ are given. Those values of k, other than zero, such that the number is identically equal to $p\ (kp+1)$, are indicated by a star (*). In addition, a list of those numbers which contain no factors of the form $p\ (kp+1)$, $k > 0$, is given, so arranged that the number of such numbers between any two limits less than 12000 is easily obtained. The table was constructed independently by two different methods, and the results compared for errors.

No. 245. Hedrick, Henry B. *Interpolation Table to Three Decimal Places.* Folio. In press.

CHEMISTRY AND PHYSICS.

No. 7. Richards, T. W., and W. N. Stull. *New Method for Determining Compressibility.* Octavo, 45 pages, 5 figures. Published 1903. Price $0.25.

In this paper the defects of many previously used methods for determining compressibility are explained, and new methods are suggested which are applicable to nearly all liquids and solids. With the help of these methods the compressibility of bromine, iodine, chloroform, bromoform, carbon tetrachloride, phosphorus, water, and glass have been determined by reference to mercury in most cases as far as 500 or 600 atmospheres. From some of these the compressibility of liquid chlorine has been inferred. Approximate determinations of the heats of compression of water and mercury have been made. A new manometer for calibrating high-pressure gauges is proposed. The compressibilities of the substances named above have been compared with regard to their relative decrease with increasing pressure. It is pointed out that usually the greater the compressibility the greater is its decrease with increasing pressure.

No. 28. Richards, T. W., and R. C. Wells. *A Revision of the Atomic Weights of Sodium and Chlorine.* Octavo, 70 pages. Published 1905. Price $0.50.

The investigation described in this monograph consisted of a very careful quantitative study of the three ratios involving the three substances—silver chloride, sodium chloride, and metallic silver. An effort was made to test every operation involved in the execution of the experiments with the greatest precision. Extraordinary precautions were taken in purifying all the substances used. The identity of materials obtained from many different sources was demonstrated in order to prove the adequacy of the methods of purification. Before weighing, all the substances were fused in vacuum in order to eliminate air and moisture. The conditions governing the irregularities attending chemical precipitation were studied more minutely than hitherto and the necessary precautions were applied. It was shown conclusively that Stas's silver must have been impure and that accordingly his atomic weight of chlorine was in error by over 0.05 per cent, while his value for sodium was nearly 0.2 per cent too high. The new values are respectively 35.473 and 23.008, if silver is provisionally taken as 107.930, each figure being diminished by 0.046 per cent if silver is taken as 107.88.

No. 56. Richards, T. W., and G. S. Forbes. *Energy Changes Involved in the Dilution of Zinc and Cadmium Amalgams.* Octavo, 68 pages, 10 figs. Published 1906. Price $0.50.

The electrochemical and thermochemical properties of liquid amalgams were investigated with a view to the further understanding of chemically generated electromotive forces. Extraordinary precautions were taken against experimental errors. Zinc amalgams gave potentials lower than those calculated from the gas law (or law of concentration-effect) and cadmium amalgams gave potentials higher than those thus calculated. As the dilution with mercury is increased, the deviations diminish, and in the most dilute amalgams investigated the closest approach to the law ever noted in the study of solutions was found. The temperature-coefficient of the potential of the cadmium amalgam cells was found to be almost identical with the tension increment of a perfect gas, while that of the concentrated zinc-amalgam cell was shown to be greater. Preliminary thermochemical experimentation supported these conclusions, and all the experiments were studied in relation to the conclusions of Helmholtz and of Cady. A part of the work has since been verified by the less comprehensive investigation of Hulett and De Lury (J. Am. Chem. Soc., 30, 1812 [1908]). This investigation is continued in publication 118.

No. 61. Richards, T. W., and G. E. Behr. *The Electromotive Force of Iron under Varying Conditions and the Effect of Occluded Hydrogen.* Octavo, 43 pages, 6 text figures. Published 1906. Price $0.25.

The object of this work was to determine with great precision the electromotive force of iron in contact with solutions of its salts, as a first step in the exact study of the very important phenomenon of rusting. It is shown that all previous investigations upon this subject were at fault because of inadequate precautions as to the purity of the iron and the exclusion of oxygen from the system. Iron in various conditions was investigated and the effect of stresses was studied. If the normal calomel electrode is taken as having a single potential difference of 0.56, pure compact iron has a single potential difference of 0.15. Occluded hydrogen was found greatly to raise this value. The facts received brief theoretical discussion. This work has since been repeated and verified by others.

No. 69. Richards, T. W., and A. Staehler, E. Mueller, G. S. Forbes, and Grinnell Jones. *Further Researches Concerning the Atomic Weights of Potassium, Silver, Chlorine, Bromine, Nitrogen, and Sulphur.* Octavo, 88 pages, 4 text figures. Published 1907. Price $0.50.

This monograph includes four papers, one having been undertaken with the help of each of the four assistants named above. The first consisted of a study of the atomic weight of potassium essentially similar to that of sodium described in publication 28, with some further precautions contributing still more to accuracy. It was shown that Stas had made the same errors in the case of potassium as in that of sodium and that the real atomic weight of this element is to be taken as 39.114, if silver is 107.93.

The second paper describes a precise study of potassium bromide. This yielded identically the same value for potassium as the chloride, leaving no doubt as to the true value of the atomic weight of this element. If silver is taken as 107.88, potassium becomes 39.096.

The third paper deals with the synthesis of silver nitrate from pure silver and pure nitric acid. In the course of the work a new and convenient apparatus for quantitative evaporation involving quartz flasks was devised. The silver nitrate was fused until constant in weight; it was carefully tested for dissolved air, retained water, and ammonia, and nitric and nitrous acids. Only the second and third of these impurities could be detected by tests proved to be adequate, and these only in mere traces, less than 0.002 per cent in all. The outcome was that if nitrogen is taken as 14.008, silver must be taken as 107.880.

The fourth paper concerns the atomic weights of silver and sulphur, which were evaluated by converting pure silver sulphate into silver chloride. The results showed that if sulphur is taken as 32.07, silver must be 107.88.

No. 76. Richards, T. W., and W. N. Stull, F. N. Brink, and F. Bonnet, Jr. *The Compressibilities of the Elements and their Periodic Relations.* Octavo, 67 pages, 8 text figures. Published 1907. Price $0.50.

Until this investigation was undertaken almost nothing was known about the compressibility of the elements. The monograph describes experiments carried out by the new method detailed in Publication No. 7. Thirty-five of the solid and liquid elements were investigated—enough to show that the compressibilities of the elements are distinctly related periodically with one another as well as with other properties such as volatility and atomic volume. Among the elements investigated, silicon was least affected by pressure, having a compressibility less than one-twentieth of that of mercury, and cæsium was found to be the most compressible among the solid elements, having a compressibility about fifteen times that of mercury. Liquid chlorine was found to be about half again as compressible as this; and other solid and liquid elements have values ranging between these extremes.

No. 118. Richards, T. W., with the collaboration of J. H. Wilson and R. N. Garrod-Thomas. *Electrochemical Investigation of Liquid Amalgams of Thallium, Indium, Tin, Zinc, Cadmium, Lead, Copper, and Lithium.* Octavo, iv+72 pages, 12 text figures. Published 1909. Price $0.50.

The connected investigations described in the two papers comprised in this monograph are a continuation of the research described in Publication No. 56. The

object was to extend the study to elements possessing other valences and to study more accurately the phenomena investigated. The electromotive forces (and their temperature coefficients) of various cells containing amalgams of the eight metals named in the title were measured, with many precautions against experimental errors. Thallium and indium were found to behave in the same manner as cadmium, but in a much more exaggerated degree. Tin and lead were found to behave in the same manner as zinc, but likewise in a more exaggerated degree. It was shown that the greater part of these deviations from the concentration law may be explained by the heat of dilution of the amalgam, according to the equation of Cady. The temperature-coefficient of a cell of this type was shown to correspond closely with the requirement of this equation. The difficulties of the actual measurement of thermochemical data involving amalgams were emphasized, and many errors in the work of previous investigators were discovered. It was shown that the deviations from the simple concentration law in every case decreased as the dilution increased, so that upon reaching a concentration of 0.01 gram-atom per liter all the amalgams investigated behaved practically as ideal solutions.

No. 125. RICHARDS, THEODORE W., and H. H. WILLARD. *Determinations of Atomic Weights.* Octavo, IV+113 pages, 4 figs. Published 1910. Price $0.75.

This book contains the following papers, *not sold separately:*

RICHARDS, T. W. and H. H. WILLARD.—Further Investigations Concerning the Atomic Weights of Silver, Lithium, and Chlorine.
RICHARDS, T. W.—Harvard Determination of Atomic Weights between 1870 and 1910.
RICHARDS, T. W.—Methods Used in Precise Chemical Investigation.

The first paper describes a new method for determining the atomic weight of silver through the ratio of lithium perchlorate to the chloride on the one hand and the ratio of the chloride to silver on the other. A new method of purifying lithium salts is described, as well as new apparatus for effecting the change of the chloride into the perchlorate. Incidentally the atomic weight of lithium was determined anew and found to be nearly 1 per cent lower than Stas's value. If oxygen is taken as 16, the investigation yielded as its result Ag = 107.871 and Li = 6.939.

The second paper contains a brief description of all the investigations concerning atomic weights which have been conducted in Harvard University, with a detailed chronological bibliography and a table comparing the results with the accepted international values.

The third paper combines the more important parts of two addresses delivered before the German Chemical Society and the American Chemical Society. It emphasizes some of the more important details necessary in exact chemical experimentation of any kind.

No. 63. *The Electrical Conductivity of Aqueous Solutions.* A Report presented by ARTHUR A. NOYES upon a Series of Experimental Investigations executed by A. A. NOYES, W. D. COOLIDGE, A. C. MELCHER, H. C. COOPER, YOGORO KATO, R. B. SOSMAN, G. W. EASTMAN, C. W. KANOLT, and W. BÖTTGER. Octavo, VI+352 pages, 20 text figures. Published 1907. Price $2.50.

This publication describes an extended series of researches on the electrical conductivity of aqueous solutions through a wide range of temperature (18° to 306°). The special apparatus which had to be constructed for the purpose is fully described. The conductivity results obtained with seventeen different salts, acids, and bases at various concentrations are presented in detail; and these results are discussed with reference to the migration-velocities of the constituent ions and the degree of ionization and hydrolysis of the substances themselves. From the hydrolysis measurements the ionization constant of water is derived for temperatures between 0 and 306°. The general conclusions to which all these researches have led are presented in a comprehensive summary at the end of the work.

No. 60. JONES, HARRY C., and F. H. GETMAN, H. P. BASSETT, L. MCMASTER, and H. S. UHLER. *Hydrates in Aqueous Solution.* Octavo, VIII+264 pages, 35 plates, 76 text figures. Published 1907. Price $2.50.

In this monograph are brought together the results of several years' work on the various lines of evidence bearing upon the "Hydrate Theory." One of the most

important of these is the evidence furnished from the lowering of the freezing-point of water with which a salt crystallizes and its power to lower the freezing-point of water when dissolved in that solvent. This is shown to be a strong argument in favor of the theory of hydration in aqueous solutions. The freezing-points of between 1,200 and 1,500 solutions of more than 100 compounds were measured, and the results are here recorded. Experimental evidence was also obtained which showed that salts dissolved in alcohol frequently combined with more or less of that solvent, forming alcoholates. The theory of hydration in aqueous solutions thus becomes the theory of solvation in solution in general.

The second part of this monograph deals with the absorption spectra of solutions from the standpoint of the hydrate theory. The absorption spectra were obtained with a grating spectroscope, and solutions both in water and in the alcohols were studied, also solutions in mixtures of the alcohols with water. The effects of concentration of the solution and of the presence of a dehydrating agent were tested; also the effect of adding varying amounts of water to the solutions in the alcohols. The results all fall in line with the hydrate theory, and can be interpreted in terms of no other conception thus far advanced.

No. 80. Jones, Harry C., and C. F. Lindsay, C. G. Carroll, H. P. Bassett, E. C. Bingham, C. A. Rouiller, L. McMaster, and W. R. Veazey. *Conductivity and Viscosity in Mixed Solvents.* Octavo, v+235 pages, 103 text figures. Published 1907. Price $2.00.

This publication deals with conductivity and viscosity in mixed solvents. The conductivities of a large number of salts in water, methyl and ethyl alcohols, and acetone were studied, and the relation between these conductivities and the viscosities of the several solvents, including especially the mixed solvents. A large number of relations were brought out, showing that the viscosity of the solvent, or solvent mixture, is a prime factor in conditioning the conductivity of dissolved electrolytes. It was shown that the effect of one associated solvent on the association of another associated solvent, with which it is mixed, is to lessen its association. The *minima* in the conductivity curves obtained in mixed solvents were also explained.

The bearing of the temperature coefficients of conductivity on the hydrate theory is discussed, and the meaning of negative temperature coefficients pointed out. The lowering of the viscosity of water produced by certain salts is considered, and the first satisfactory explanation of this important phenomenon given.

No. 110. Jones, Harry C., and John A. Anderson. *The Absorption Spectra of Solutions.* Octavo, vi+110 pages, 81 plates. Published 1909. Price $3.50.

This monograph deals entirely with the absorption spectra of solutions of certain salts of cobalt, nickel, copper, iron, chromium, neodymium, praseodymium, and erbium in water, methyl alcohol, ethyl alcohol, and acetone; and in mixtures of water with the other solvents. The work recorded takes up the subject of the absorption spectra of solutions in a fairly comprehensive manner. Among the problems studied are the effect on the absorption of light produced by changing the concentration of the solution but keeping the total amount of coloring matter in the path of the beam of light constant; the effect of dehydrating agents; the absorption spectra in methyl and ethyl alcohols, as well as in water and in acetone, is also brought within the scope of this work.

Some surprising results were obtained, especially with the salts of neodymium in the alcohols. It was found that neodymium chloride showed one set of bands in aqueous solutions, but some entirely *new bands* made their appearance in the alcoholic solutions. In mixtures of water with the alcohols both sets of bands came out simultaneously. The nature of absorption of light by solutions in general is discussed at some length. Heliotype reproductions of 81 plates of spectrograms are given, including about 1,200 solutions. All these data are explained with perfect ease by means of the general theory of *solvation* in solution, but a large number of the facts brought to light in this work are not explicable in terms of any other suggestion thus far advanced.

No. 130. Jones, Harry C., and W. W. Strong. *A Study of the Absorption Spectra of Solutions of Certain Salts of Potassium, Cobalt, Nickel, Copper, Chromium, Erbium, Praseodymium, Neodymium, and Uranium as affected by Chemical Agents and by Temperature.* Octavo, ix+159 pages, 98 plates. Published 1910. In cloth binding. Price $5.00.

This is a continuation of the work described in Publications Nos. 60 and 110. The results obtained from the study of about 3,000 solutions are herein recorded.

The effect of the addition of free acids and foreign salts on absorption spectra show that chemical reactions are probably much more complex than we usually suppose. It was found that solvents which do not absorb visible light may have a marked influence on the absorption of the dissolved substance. Definite solvent bands have been discovered for water, the alcohols, acetone, and glycerol. These bands are characteristic of each solvent, and the proof of their existence is regarded as strong evidence for the theory of solvation in solution. It is difficult, not to say impossible, to see how the solvent can produce such a marked effect upon the resonance of the vibrators in solutions unless it enters into some kind of combination with the dissolved substance. The evidence for the solvate theory having become so strong, a brief discussion of the significance of that theory is given. It is shown that when we supplement the theory of electrolytic dissociation by the theory of solvation we have a satisfactory theory of solution.

A fairly large amount of work was done on the effect of temperature on the absorption spectra of solutions, and the results are recorded. A bibliography of the publications from this laboratory on the solvate theory of solution is appended.

No. 160. Jones, Harry C., and W. W. Strong. *The Absorption Spectra of Solutions of Comparatively Rare Salts, including those of Gadolinium, Dysprosium, and Samarium; the Spectrophotography of Certain Chemical Reactions, and the Effect of High Temperature on the Absorption Spectra of Non-aqueous Solutions.* Octavo, viii+112 pages, 67 plates. Published 1911. In cloth binding. Price $4.00.

The results of the study of three problems are herein recorded, and the absorption spectra of a number of rare substances are mapped. Salts of dysprosium and samarium have spectra that are almost as interesting as those of neodymium. The spectra of a number of salts in a large number of organic solvents were studied and "solvent bands" were found for a number of the solvents used. Isomeric solvents showed different bands for a given salt. The second problem was the change in the spectrum which takes place as one salt of a metal is transformed into another salt. The effect of oxidizing agents on uranous salts was especially investigated. Mild oxidizing agents oxidized the "hydrated" salt and left unaffected the "alcoholated" salt—an example of selective oxidation. The effect of rise in temperature on the absorption spectra of solutions was also studied. By means of a closed cell, devised for the purpose, temperatures as high as 195° were used with alcoholic solutions. The absorption bands widen with rise in temperature, colored solutions in general becoming more opaque. It was also found that the "water" bands of any given salt are more affected by rise in temperature than the "alcohol" bands; showing that the hydrates are less stable with rise in temperature than the alcoholates. These are but a few of the many relations brought out by the work.

No. 170. Jones, Harry C., and A. M. Clover, H. H. Hosford, S. F. Howard, C. A. Jacobson, H. R. Kreider, E. J. Shaeffer, L. D. Smith, A. Springer, Jr., A. P. West, G. F. White, E. P. Wightman, and L. G. Winston. *The Electrical Conductivity, Dissociation, and Temperature Coefficients of Conductivity, from Zero to Sixty-five Degrees, of Aqueous Solutions of a Number of Salts and Organic Acids.* Octavo, iv+148 pages, 5 text figures. Published 1912. Price $1.50.

The work recorded in this monograph was undertaken especially because, when reference is made to the literature for the conductivity of any electrolyte at any given temperature, and for the temperature coefficients of conductivity, it is frequently difficult to find what is desired; or, if found, the data may be so discordant

that it is impossible to decide as to the true conductivities and dissociations in question. Since the magnitude of the dissociation of any electrolyte is fundamental to its scientific use in chemistry, it is desirable that such data should be made available over the range of temperature most frequently used in the laboratory. With this idea in mind, the work has now been continued until it represents more than twenty years' continuous labor for one man, about 40,000 conductivity measurements having been made. The conductivities and dissociations of about 110 of the more common salts have been worked out from zero to 65 degrees, and over a range in dilution extending from about the most concentrated solution that could be used to the dilution of complete dissociation. The temperature coefficients of conductivity have been calculated in both conductivity units and per cent. Similar data have been obtained for about 90 of the more common organic acids, and their constants have been calculated by means of the Ostwald dilution law.

No. 180. Jones, Harry C., assisted by C. M. Stine, J. N. Pearce, H. R. Kreider, E. G. Mahin, M. R. Schmidt, J. Sam. Guy, and P. B. Davis. *The Freezing-Point Lowering, Conductivity, and Viscosity of Solutions of Certain Electrolytes in Water, Methyl Alcohol, Ethyl Alcohol, Acetone, and Glycerol, and in Mixtures of these Solvents with one another.* Octavo, vii+214 pages, 85 text figures. Published 1913. Price $2.00.

The seven pieces of work incorporated in this monograph are a continuation of the investigations recorded in monograph No. 80. The effect of one hydrated salt on the hydration of another hydrated salt was worked out with a number of pairs of salts. The dissociation of a number of salts was determined by the freezing-point and conductivity methods. It was shown that the atoms or ions with the smallest volumes have the greatest hydrating power. The relation between hydrating power and electrical density is discussed. The dissociation in the alcohols was determined by the improved conductivity method.

Three investigations had to do with the physical chemistry of glycerol as a solvent. The conductivity and viscosity of solutions in glycerol as a solvent were studied at different temperatures, glycerol being a liquid solvent with enormous viscosity. The temperature coefficients of both conductivity and viscosity in glycerol were very great. The salts of ammonium and rubidium were found to lower the viscosity of glycerol. The explanation of this phenomenon, offered by Jones and Veazey in monograph No. 80, for aqueous solutions, was found to apply equally well for solutions in glycerol as the solvent.

No. 190. Jones, Harry C., and J. S. Guy. *The Absorption Spectra of Solutions as Affected by Temperature and by Dilution: A Quantitative Study of Absorption Spectra by Means of the Radiomicrometer.* Octavo, vii+93 pages, 22 plates, 44 text figures. Published 1913. Price $2.00.

A form of closed apparatus was devised and used for studying the absorption spectra of aqueous solutions up to 200°. It was found that the absorption bands widen with rise in temperature. The effect of dilution on the absorption spectra of solutions was also investigated over a range of dilution varying from 1 to 500. The absorption increased with the concentration, especially towards the red end of the spectrum. A radiomicrometer was built and used for studying absorption spectra quantitatively. This permitted work at much greater wave-lengths than was possible by means of the grating spectroscope and photographic plate. The former was limited to λ 7,600, while the latter can be used as far as λ 30,000, and even farther. The effect of dilution was also studied quantitatively by means of the radiomicrometer, and interesting and important results were obtained in reference to the effect of dilution on the nature and position of the transmission bands. It was found that "free" water had a different absorption from "combined," and this was regarded as further evidence for the solvate theory of solution. The absorption spectra of a fairly large number of salts were mapped by means of the radiomicrometer.

No. 210. Jones, Harry C., with E. J. Shaeffer, E. P. Wightman, P. B. Davis, L. D. Smith, M. G. Paulus, J. B. Weisel, A. Holmes, H. Hughes, and W. S. Putnam as collaborators. *The Absorption Spectra of Solutions as Studied by means of the Radiomicrometer. The Conductivities, Dissociations, and Viscosities of Solutions of Electrolytes in Aqueous, Non-aqueous, and Mixed Solvents.* Octavo, 202 pages, 1 plate, 58 text figures. Published 1915. Price $1.75.

In the investigations recorded in the above-named publication it was found that solutions of non-hydrated salts are equally absorbent with pure water, except at the bottoms of the bands where the solutions are more opaque. Solutions of hydrated salts are more transparent than pure water, showing that combined water has less absorption than free water. This is regarded as strong evidence in favor of the solvate theory of solution.

The work on the conductivities and dissociations of the organic acids in both water and alcohol has been extended, and some results of interest, especially in alcohol, are included in this volume.

The work in mixed solvents, the earlier results of which have already been published in Nos. 80 and 180 of this series, has been extended. An elaborate study has been made of a few salts in binary mixtures of ethyl alcohol and water, of acetone and water and in ternary mixtures of acetone, glycerol, and water, and the results are recorded in this monograph.

Work bearing directly or indirectly on the solvate theory of solution has been in progress for about 15 years in the Chemical Laboratory of the Johns Hopkins University; and many papers dealing with the subject have been published in American, German, French, and English scientific journals. The Carnegie Institution of Washington, which has assisted the work with grants during much of this time, has also published nine monographs on various phases of the subject.

Some of the more important points established in all of this work are summarized in the last chapter of the present publication.

No. 230. Jones, Harry C., with P. B. Davis, W. S. Putnam, E. J. Shaeffer, M. G. Paulus, J. F. Hutchinson, J. E. L. Holmes, G. C. Connolly, H. H. Lloyd, J. B. Wiesel, C. Watkins, G. F. Ordeman, A. G. McCall, F. M. Hildebrandt, F. S. Holmes, E. S. Johnston, and S. F. Trelease as collaborators. *Conductivities and Viscosities in Pure and in Mixed Solvents, Radiometric Measurements of the Ionization Constants of Indicators.* Octavo, vii+175 pages, 3 plates, 21 text figures. Published 1915. Price $2.00.

The viscosities of solutions of cæsium salts in mixed solvents and in mixtures of the associated liquids, water, formic acid, and acetic acid were studied in their bearing on the theory of viscosity proposed by the principal author some years ago. The dissociation of salts in formamid was measured in connection with the relation between the dissociating power of solvents and their dielectric constants.

A new grating spectroscope and radiomicrometer were employed in working out the ionization constants of indicators and satisfactory results were obtained for a few of the indicators more commonly used in analytical work.

The relative chemical activity of free and of combined water was investigated in connection with the velocities with which they saponified an ester and hydrated acetic anhydride. The conductivities of a number of the more common organic acids in ethyl alcohol and in several of the less common salts in water were measured. It was found that combined water probably had less dissociating power than free water. The absorption and adsorption of potassium chloride by soils are of both scientific and technical importance. Potassium chloride is partly absorbed or combined chemically with the soil particles and partly adsorbed or in a state of physical union with the particles of the soil.

No. 35. Coblentz, W. W. *Investigations of Infra-red Spectra. Part I. Infra-red Absorption Spectra. Part II. Infra-red Emission Spectra.* Octavo, 331 pages, 152 text figures. Published 1905. Price $1.75.

A spectroradiometric investigation of the most important groups of chemically related compounds to determine what effect certain groups of atoms have upon the transmission of radiant energy. Part I describes the absorption spectra of 135 substances, including solids, liquids, and gases, many being organic compounds. The observations extend from the visible spectrum to wave-length 0.015 mm. in the infra-red. Many absorption bands were identified with certain groups of atoms, *e. g.*, with CH_3, NH_4, NO_2, OH, NCS, etc. Five appendices are added, which deal with subsidiary problems, such as radiometers, absorption of solids in solution, etc.

Part II gives the results of a radiometric investigation of the emission spectra of various metals in the carbon arc and of gases in a vacuum tube.

No. 65. Coblentz, W. W. *Investigations of Infra-red Spectra. Part III. Infra-red Transmission Spectra. Part IV. Infra-red Reflection Spectra.* Octavo, 128 pages, 93 text figures. Published 1906. Price $1.00.

A continuation of the investigation described in No. 35. In Part III the results obtained in Part I are applied to gain information with regard to the molecular structure of minerals containing oxygen and hydrogen in the form of "water of crystallization" and of "water of constitution." It is shown that the spectra of minerals containing "water of crystallization" have absorption bands identical with those of water, while "water of constitution" shows no such bands.

In Part IV are described the reflection spectra of various minerals, such as, for example, sulphides, sulphates, silicates; also solutions of these substances and metals not heretofore examined. These investigations extend to wave-length 0.015 mm. in the infra-red, and many of these substances are shown to have bands of strong selective reflection.

Five appendices are added, in which are described the emission spectrum of carbon disulphide, a new radiomicrometer, methods of blowing quartz fibers, and a discussion of the possibility of the observed radiation from the moon being due, in part, to selectively reflected solar energy.

No. 97. Coblentz, W. W. *Supplementary Investigations of Infra-red Spectra. Part V. Infra-red Reflection Spectra. Part VI. Infra-red Transmission Spectra. Part VII. Infra-red Emission Spectra.* Octavo, 183 pages, 107 text figures. Published 1908. Price $1.25.

This is an extension of the investigations which are described in Nos. 35 and 65. Part V gives the reflection spectra of various substances, including sulphides, oxides, carbonates, and silicates not previously obtainable. In the sulphides and carbonates the long-sought-for shift of the maximum of the reflection or absorption band with change in atomic weight of the basic element (which is joined to the CO_2 or SO_4 radical), which was described in No. 65, was definitely established. A minute examination of the reflection bands of quartz (crystalline and amorphous glass) and of carbonates was made; and by means of residual rays the reflection spectra are extended to the remote parts of the infra-red to wave-lengths 0.03 to 0.04 mm.

In Part VI the transmission spectra of various solutions, of colloidal metals, and of colored glasses are described, and the effect of special groups of atoms on radiant energy is considered in detail. Part VII is an extension of Part II and describes the arc and spark spectra of metals in hydrogen, to verify the previous work, which showed that no strong emission lines exist in the deep infra-red. New and important results were obtained on the vapors of the carbon arc. The radiation of the Rubens thermopile to a vessel of liquid air was investigated, showing that the pile is a very complete radiator and absorber of radiant energy. The Nernst glower is shown to have a discontinuous spectrum at low temperatures, which becomes continuous at high temperatures. Various solids (many heated electrically, like the Nernst glower) are shown to have discontinuous spectra with emission bands which are as sharp as those of gases.

The emission of the new metals (used in incandescent lamps) was investigated, and it was found that the so-called "constants" of radiation are really functions of

the temperature and the wave-length. From a consideration of the reflecting power it is shown that metals must emit selectively in the visible spectrum. The radiation from selectively reflecting bodies, with special reference to lunar radiation, is again discussed; also the effect of the surrounding medium upon the emission of a substance.

Three appendices are added, the most important one being on instruments and methods used in radiometry, in which the radiometer, thermopile, radiomicrometer, and bolometer are compared, both historically and by means of experimental data. In each volume the author indicates problems requiring further investigation as well as new fields of research.

No. 164. Coblentz, W. W. *A Physical Study of the Firefly.* Octavo, 47 pages, 1 plate, 14 text figures. Published 1912. Price $0.50.

In this paper are discussed the production, the composition, and the functions of the light emitted by fireflies. Luminous efficiency, candle-power, radiation, and temperature measurements are given; also data on the fluorescent substance found in fireflies. The lights of various species of fireflies and of a standard lamp were photographed, and the densities compared by means of spectrophotographic photometry. In this manner the spectral energy curve of the light of the firefly was deduced from a knowledge of the spectral energy curve of the standard lamp. It is shown that the color of the light of the firefly is not a subjective phenomenon, the maximum emission of the *Pyrophorus noctilucus* being at 0.538μ, *Photuris pennsylvanica* being at 0.522μ, *Photinus pyralis* being at 0.567μ, *Photinus consanguineus* being at 0.578μ.

No. 71. Uhler, H. S., and R. W. Wood. *Atlas of Absorption Spectra.* Quarto, 59 pages, 26 plates, 7 figures. Published 1907. Price $1.50.

The selective absorptions for light of about 180 aqueous solutions of the aniline dyes are described in the text as well as presented graphically by the photographic reproductions of the plates. The dispersion used was practically normal, and the region of the spectrum investigated extended from 0.20μ to about 0.65μ. A few inorganic substances possessing absorption bands of especial interest were also studied and the results incorporated in the text and plates. Complete data are given, so that the absorption bands can be readily reproduced quantitatively whenever absorbing screens are needed for photographic or other purposes.

No. 29. Baird, J. W. *The Color Sensitivity of the Peripheral Retina.* Octavo, 80 pages. Published 1905. Price $0.50.

This paper is the result of a physical investigation made by the author during 1903-4 in the Psychological Laboratory of Cornell University and is a contribution to the knowledge of phenomena of indirect vision. The author presents data obtained by him in a series of experiments upon the peripheral retina, and correlates these data with the phenomena previously established and with the theoretical principles advanced from time to time by other investigators.

No. 44. Scripture, E. W. *Researches in Experimental Phonetics. The Study of Speech Curves.* Quarto, 204 pages, 13 plates, 138 text figures. Published 1906. Price $2.00.

These investigations had their origin in an attempt to apply physical methods in studying the nature of verse. The work was begun at Yale University, and was continued at Munich, where a laboratory was installed and valuable assistance received from the Psychological Laboratory of the University of Munich. The work was later continued at the Psychological Laboratory of the University of Berlin. The volume gives an account of the apparatus used in recording sounds and of the methods applied in obtaining speech curves. A chapter on qualitative analysis indicates how phonetic facts may be read directly from the speech curves without measurement. It is also explained how such fundamental factors of speech as melody, duration, and amplitude can be obtained from the curves by simple methods of measurement. The method of harmonic analysis is carefully considered, the theories of vowel productions are discussed, and detailed examples of vowel analysis are given.

No. 57. Washington, H. S. *The Roman Comagmatic Region.* Octavo. For description see page 48.

No. 31. Day, Arthur L., E. T. Allen, J. P. Iddings, and G. F. Becker, *The Isomorphism and Thermal Properties of the Feldspars. Part I, Thermal Study; by A. L. Day and E. T. Allen. Part II, Optical Study; by J. P. Iddings, with an Introduction by G. F. Becker.* Octavo, 95 pages, 26 plates, 25 text figures. Published 1905. Price $1.75.

An investigation of the relation between the feldspars of the lime-soda series undertaken partly in an endeavor to settle an old question of great petrological interest and partly to establish the fact that minerals in solution with one another differ in no essential particular from other solutions and obey the same fundamental laws. The materials are chemically pure feldspar types prepared in the laboratory; the methods are those of quantitative chemistry, physics, and physical chemistry, and the field covers the entire temperature range of feldspar formation up to 1540° C. Many of the phenomena occurring at these extreme temperatures differ widely from those commonly observed at ordinary temperatures and are thus broadly interesting from the viewpoint of the properties of matter. In particular, it was discovered that among the minerals it is not uncommon for the solid state to persist for hours or even days at a temperature considerably above the melting-point, a phenomenon which has never been observed before.

No. 157. Day, Arthur L., and Robert B. Sosman. *High Temperature Gas Thermometry. With an Investigation of the Metals, by E. T. Allen.* Octavo, vi+129 pages, 1 plate, 18 figures. Published 1911. Price $1.25.

An account of a new determination, with the nitrogen thermometer, of the fundamental scale of temperatures, beginning with 400° C. and extending to 1550° C. Its purpose was partly to increase the accuracy of the existing (Reichsanstalt) scale. which reaches only to 1100°, but more particularly to extend the scale beyond this temperature as far as it should prove practicable to go without serious sacrifice of accuracy. It proved possible to establish the melting-point of pure palladium (1549.5°) with a probable uncertainty of no more than 2°.

Two bulbs were used, one of platinum containing 10 per cent of iridium, the other of platinum containing 20 per cent of rhodium. The latter material proved to be better suited to the purpose than any which has hitherto been tried. In the experimental development of the problem, the errors of the older (Reichsanstalt) instrument, so far as known, were reduced to about one-fourth of their former magnitude. The apparatus and its limitations, together with all the results obtained with it in a period of nearly five years, are described in considerable detail.

No. 158. Wright, Fred. Eugene. *The Methods of Petrographic-Microscopic Research: Their Relative Accuracy and Range of Application.* Octavo, 204 pages, 11 plates, 118 figs. Published 1911. (Out of print.) Price $2.50.

In this paper the petrographic microscope is treated as a measuring device for the exact determination of the optical properties of crystal plates, especially of minute crystal fragments and crystallites. The methods now available for the purpose are considered with special reference to their accuracy and applicability to the investigation of fine-grained silicate preparations. The factors underlying the determination of any given optical property are discussed in detail, and the attempt is made in each case to ascertain the absolute accuracy attainable.

No. 40. Barus, Carl. *Nucleation of the Uncontaminated Atmosphere.* Octavo, xii+152 pages, 104 text figures. Published 1906. Price $1.00.

This book contains as its chief feature a record of the dust content of the air at Block Island, Rhode Island, in comparison with identical observations made at the same time in Providence, Rhode Island, throughout the winter of 1904-1905. In winter the former locality is relatively uninhabited and is surrounded by water on all sides. It is shown that the time distribution of nuclei in both places is qualitatively the same, although in Providence it is four to ten times larger quantitatively. In the introductory chapters a number of independent correlative experiments are included, referring to condensation on ions and on the vapor nuclei (colloidal nuclei) of dust-free wet air, to the production and distribution of persistent nuclei pro-

ducible by the X-rays, to the penetration of radium radiation through different media and different distances, etc., all interpreted by measuring the apertures of the coronas of cloudy condensation. The corresponding nucleation is computed as shown in the author's earlier papers.

No. 62. BARUS, CARL. *Condensation of Vapor as induced by Nuclei and by Ions.* Octavo, x+164 pages, 66 text figures. Published 1907. Price $1.50.

The purpose of this book is the development of a capacious fog-chamber, efficient enough to capture the ions and the vapor nuclei of dust-free wet air by condensation, to the extent in which their number per cubic centimeter may be measurable by aid of the coronas of cloud particles. As the apertures of the coronas eventually become very large, approaching 60°, and a reasonable exhibit of coronal colors is essential for identification, the need of a large apparatus is apparent. Equations are deduced for the practical treatment of the variables involved. Experiments made with water and alcoholic vapors in different gases establish the nature of the vapor nuclei of dust-free media. In continuation of the atmospheric work of the preceding report, a comparison is made of the ionization and the dust contents of the atmosphere in a series of observations extending over several months; also of the ionization of dust-free wet air in the lapse of time, as exhibited by the fog-chamber.

No. 96. BARUS, CARL. *Condensation of Vapor as induced by Nuclei and by Ions.* Report III. Octavo, vi+139 pages, 48 text figures. Published 1908. Price $1.25.

After summarizing the thermodynamic equations which determine the efficiency of the plug-cock fog-chamber, the author continues his work on the changes of the incipient nucleation (ionization) of dust-free wet air in the lapse of time. No periodic variations are detected, but the vapor nucleation changes about 2 per cent per degree centigrade. A new series of experiments is then undertaken to standardize the coronas of cloudy condensation in dust-free air in terms of the nucleation represented. This is done both by the old method of diffraction from a single point of light and by a new method in which the coronas from two sources are brought into contact. The results obtained are next applied for exhibiting the distribution of ions and vapor nuclei in dust-free wet air in relation to size. Finally, a systematic study is made of the behavior of residual water nuclei, *i. e.,* nuclei of pure water obtained from the evaporation of fog-particles precipitated on vapor nuclei or on ions in dust-free wet air. More nuclei are lost after evaporation in the cases of ions as compared with the cases of vapor nuclei, and the initial evaporation is always preponderating in its destructive effect.

No. 96. (Part II.) BARUS, CARL. *Condensation of Vapor as induced by Nuclei and by Ions.* Report IV. Octavo, viii+84 pages, 21 text figures. Published 1910. Price $0.75.

In the first part of this report the author treats the properties of the nuclei of water vapor, showing among other things that they persist longer in proportion as the evaporation of the parent fog-particles is more rapid. The standardization and efficiency of fog-chambers are then taken up, the results being tested by the coronas of monochromatic light (mercury vapor). These results have a direct bearing on the theory of coronas. Some space is given to the displacement of ions by exhaustion, as evidenced by the occurrence of maxima of ionization in the fog-chamber. Finally, the attempt is made to standardize the coronas by the aid of Thomson's electron, the charge of which is known. Independent methods, using either the velocity of the ions or the decay constants, are tested for this purpose. The voltaic potential difference between conductors separated by an ionized medium is investigated.

No. 149. BARUS, CARL. *Production of Elliptic Interferences in Relation to Interferometry.* Octavo, vi+77 pages, 33 figs. Published 1911. Price $1.25.
Part II. Octavo, pages vi+79–168, figs. 34–64. Pub. 1912. Price $1.00.
Part III. Octavo, pages vi+169-273, figs. 65-119. Pub. 1914. Price $1.00.

In the cases of coronas there is a marked interference phenomenon superposed on the diffractions. This suggested the present investigation, which aims at a sim-

plification of the effect in question by bringing two complete component diffraction spectra, from the same source of light, to interfere. Many ways are shown to be available, the methods being either direct (as discussed in Chapters II and III, where a plane mirror immediately behind the grating returns reflected-diffracted and diffracted-reflected rays) or indirect, using the devices of Jamin, Michelson, and others (Chapters IV and V). In Chapter I a modification of Rowland's apparatus, suitable for plate gratings, is described. The direct method gives equidistant fringes, duplex in character, but rigorously straight throughout the spectrum, their distances apart and inclination being measurable by ocular micrometry. Lengths and small angles are thus subject to micrometric measurement. In case of the indirect method, the half-silvered plate is replaced by the grating; the fringes are, as a rule, approximately elliptic (confocal) throughout the spectrum, and the fringes again partake of both a drift and a radial motion when the interferometer adjustment is altered. Drift and radial motion may be regulated in any ratio. The theory of the subject is worked out, in so far as it bears on the practical results obtained.

Part II is in the main a direct continuation of the preceding and refers chiefly to applications of the displacement interferometer. The first section describes certain interferences obtained when two originally coplanar halves of a reflecting grating move normally to the ruled surface, the line of separation being parallel to the rulings. It suggests the occurrence of interference rings when the source of light in the case of coronas is not simple but a doublet of two interfering beams, and that, for layers of fog-particles whose distance apart is commensurate with wave-length, interferences should be superimposed on the coronal diffractions as actually observed.

Certain subsidiary investigations follow: The effect of the thickness of the cloud layer on the type of corona obtained; on the efficiency, *cæt. par.*, of different sizes of fog-chambers; on the rate of decay of different sizes of nuclei, etc. The displacement equation adduced in the first report is rigorously tested, a method for measuring the dispersion of a fragment of plate glass being devised for the purpose. Finally, a type of interferometer specially suited for displacement work is constructed. This instrument is thereupon put to the test in the endeavor to measure relations connected with the adiabatic expansion of gases, and other phenomena in which instantaneous registry by aid of the index of refraction of the gas is serviceable.

Part III records a variety of investigations made at widely different times, but in all of which the displacement interferometer was used as a basis of measurement.

No. 186. Barus, Carl. *Diffusion of Gases through Liquids, and Allied Experiments.* Octavo, vi+88 pages, 38 figs. Published 1913. Price $1.00.

In 1900 the author began a series of experiments to determine the rate at which gases diffuse out of a submerged Cartesian diver through water. The method proved to be remarkably sensitive and the results striking. In the present volume the method is perfected, with a view to completing the measurements within a reasonably short interval of time. Diffusions of air, hydrogen, and oxygen into each other, through water and a variety of solutions, are investigated in detail and the diffusion constants determined. It is shown that a method of exploring the internal channels or physical pores of liquids is probably in question. In the course of the work a number of other applications are included; for instance, the disk of an absolute electrometer is floated on a Cartesian diver submerged in hydrocarbon oil, and the potential is measured absolutely by the pressure needed to just suspend the diver in the liquid. All these results are given in full and in most cases charted, the curves being often of singular complication. It is shown why diffusion frequently occurs against the apparent pressure gradient.

No. 229. Barus, Carl. *Experiments with the Displacement Interferometer.* Octavo, vi+113 pages, 66 figs. Published 1915. Price $1.00

This volume contains applications of the displacement interferometer to subjects largely depending on minute angular measurement. Although a location free from tremor and irregular temperature variations could not be found, the development of methods of the kind in question was quite feasible; and without attempting to push them to a limit, their ranges of application could be fully investigated.

Among the subjects selected for treatment was the horizontal pendulum. In Chapter I certain available forms of the pendulum, with and without a float, are considered and tested as to their discrepancies, through long lapses of time, by a reflection method. Thereafter the interferometer itself is used, a serviceable method of application worked out and the range of application studied through many months. With a relatively very wide scope (several seconds of arc) there should be no difficulty, under proper surroundings, of measuring changes of inclination as small as 3×10^{-4} seconds of arc per interference ring.

In Chapter II an attempt is made to use this interferential horizontal pendulum, for the measurement of the gravitational attraction of two parallel disks. What was obtained, however, was a definite repulsion of the disks, decreasing with their distance apart and appreciable even within 1.5 mm. of this distance.

Chapter III is introduced as a severe test on the interference equation employed, for the case of path differences resulting when glass columns as much as 10 inches long are inserted in one of the component beams of the displacement interferometer. It appears that the constants of any dispersion formula may be obtained directly from these observations.

In Chapter IV a number of incidental experiments, on allied subjects, have been grouped together. The possible bearing of certain disk colors of circular gratings, on the somewhat similar phenomenon in coronas, is discussed, as well as the performance of the easily available film grating to replace the ruled glass grating, for purposes of displacement interferometry, from a practical standpoint. An interesting case of regular reflection and refraction of *scattered* light, bearing on the X-ray phenomena, is also discussed.

In Chapter V, finally, following the suggestive experiments made in an earlier report, the displacement interferometer is directly applied to the quadrant electrometer. The sensitiveness obtained in this way should be of the order of a millionth of a volt per vanishing interference ring.

No. 88. Bjerknes, V., and Collaborators. *Dynamic Meteorology and Hydrography.* Quarto.

This work will constitute an advanced mathematico-physical treatise on the dynamics and thermodynamics of the atmosphere and the ocean, the main aim being to develop rational methods, based on the principles of dynamics and thermodynamics, for the investigations in meteorology and oceanography.

Part I, Statics, by V. Bjerknes and J. W. Sandström. Pages 146+1*a*-36*a*, 1*b*-30*b*, and 1*c*-22*c*. Published 1910. Price $5.50. (Out of print.)

This part deals with the conditions of equilibrium in atmosphere and hydrosphere, and contains a full development of the use which can be made of the equation of hydrostatics for working out the results of observations obtained by the meteorological ascents in the air or by hydrographical soundings. It is shown how complete representations of the fields of pressure and of mass in atmosphere and in hydrosphere can be derived from the observations obtained in this way, and the book contains a complete set of numerical tables for use in performing this work. The uses of the developed methods are illustrated by several extensive examples.

Part II. Kinematics, by V. Bjerknes, Th. Hesselberg, and O. Devik. ix+175 pages, 113 text figures. (With Atlas of 60 charts.) Published 1911. Price $6.00.

This part of the work deals with the principles for drawing charts representing the fields of motion in atmosphere and hydrosphere, and develops the practical methods required for passing from the single observations to these continuous representations of the motion. From the observation, charts representing the horizontal component of the motion are first derived. These charts being found, it is shown how other charts, representing the vertical component of the motion, can be derived by making a proper use of the hydrodynamic surface-condition and of the equation of continuity. The methods are also developed for deriving charts of acceleration from two charts representing the velocities observed at two successive epochs. The

methods used in drawing these different kinds of charts may be considered as examples of a special "graphical algebra" and "graphical differential and integral calculus," of which the fundamental principles are developed in two special chapters.

This part is accompanied by 60 plates, 24 of which give a bathymetrical and hypsometrical map of the world on the scale 1 : 20,000,000, destined for use in meteorological and hydrographical investigations. The others give examples of atmospheric fields of motion.

PART III, DYNAMICS (in preparation).

No. 152. NICHOLS, EDWARD L., and ERNEST MERRITT. *Studies in Luminescence.* Octavo, 226 pages, 190 text figures. Published 1912. Price $2.00.

This volume contains an account of researches carried on in the Physical Laboratory of Cornell University (1903–1910) with the aid of grants from the Carnegie Institution of Washington. It is a report of progress, giving results obtained by the application of quantitative methods and particularly by the use of the spectrophotometer in the study of the spectra of fluorescent and phosphorescent substances. Important portions of the work were done, at the suggestion of the authors, by Drs. Frances G. Wick, C. A. Pierce, Percy Hodge, and C. W. Waggoner, and by Messrs. H. E. Howe and Carl Zeller.

The list of topics includes:

Spectro-photometric studies of fluorescent solutions belonging to Lommel's first class and of rhodamin, resorcin-blau, chlorophyl, uranium glass, fluorite, and æsculin.

Determinations of the absorbing power and fluorescence of resorufin.

The luminescence of Sidot blende when excited by Roentgen rays, its photo-luminescence during excitation, and its phosphorescence spectrum.

The decay of phosphorescence in Sidot blende and other substances.

The influence of red and infra-red rays on photo-luminescence, including the effects before, during, and after excitation and the variation in the effect with the wave-length of the active rays.

Studies of thermo-luminescence: variations in the rate of decay of Sidot blende and calcium sulphide as the result of heating.

Phosphorescence of short duration.

Photographic determinations of the distribution of energy in the fluorescence spectrum and the phosphorescence spectrum of Sidot blende.

Photographic studies of phosphorescence at room temperature, of the decay of phosphorescence, of the effect of infra-red rays, and of the influence of temperature on certain fluorescence spectra.

Kathodo-luminescence of willemite and Sidot blende and its dependence on current discharge and potential.

The electrical properties of fluorescent solutions and vapors.

Fluorescence absorption.

The energy curves of fluorescence spectra.

The specific exciting power of different wave-lengths of the visible spectrum in the cases of eosin and resorufin.

The theory of Wiedemann and Schmidt.

Phosphorescence from the standpoint of the dissociation theory.

No. 135. BAXTER, G. P., in collaboration with M. A. HINES, H. L. FREVERT, J. HUNT WILSON, F. B. COFFIN, G. S. TILLEY, EDWARD MUELLER, R. H. JESSE, JR., and GRINNELL JONES. *Researches upon the Atomic Weights of Cadmium, Manganese, Bromine, Lead, Arsenic, Iodine, Silver, etc.* Octavo, VII+185 pages, 5 text figures. Published 1910. Price $2.00.

This book consists of a collection of papers upon the atomic weights of certain common elements, and embodies the results of researches of which the experimental work has been carried on in the Chemical Laboratory of Harvard College during the years 1904–1909. The following are the subjects of the individual investigations: The analysis of cadmium chloride, the analysis of cadmium bromide, the analysis of

manganous bromide and chloride, the synthesis of silver bromide and the ratio of silver bromide to silver chloride, the analysis of lead chloride, the analysis of silver arsenate, the synthesis of silver iodide and the ratio of silver iodide to silver bromide and silver chloride, the analysis of iodine pentoxide, the analysis of silver chromate, the analysis of silver dichromate, and the analysis of silver phosphate.

No. 153. KING, ARTHUR S. *The Influence of a Magnetic Field upon the Spark Spectra of Iron and Titanium.* Quarto, III+66 pages, 6 plates, 3 text figures. Published 1912. Price $1.50.

The investigation covers the effect of a magnetic field upon 1,120 lines in the iron and titanium spectra between the limits λ 3660 and λ 6743, with discussion of experimental methods, brief historical treatment, and full discussion of the results with reference both to existing theories of the Zeeman effect and the effect of other physical conditions upon spectra. A large portion of the range of wave-length examined has not been covered in previous work with the magnetic field, while the high dispersion employed and the attention to the weaker lines give much new data for those parts of the spectrum already treated to some extent. The large range of wave-length has made it possible to study the change of the average separation of Zeeman components with increase of wave-length, bringing out the important result that for both spectra the average separation increases with the square of the wave-length. The material shows clearly how generally the separations, both simple and complex, are related to a fundamental interval involving the accepted value of e/m. Fifty-seven lines having five or more clearly resolved components are examined with respect to the commensurability of their separations. Among these complex lines many cases of magnetic duplicates are pointed out. This indicates a similarity of the vibrations producing such lines which will aid in the consideration of their behavior under other physical conditions. An extended comparison is made of magnetic separation and pressure displacement for the lines of iron and titanium, showing to what degree a correspondence exists. Examples of dissymmetry in separation are noted, including the small dissymmetry of triplets and dissymmetries so large as to be classed as abnormal separations.

No. 198. MORSE, H. N. *The Osmotic Pressure of Aqueous Solutions: Report on Investigations made in the Chemical Laboratory of the Johns Hopkins University during the years 1899-1913.* Octavo, 222 pages, 5 plates, 49 text figures. Published 1914. Price $2.00.

This work gives an account of the investigations in osmotic pressure of Professor Morse and his collaborators, Doctors Frazer and Holland. They extend over the period 1899-1913, and were carried out in the chemical laboratory of the Johns Hopkins University with the aid of grants from the Carnegie Institution.

Particular attention has been given to the development of the apparatus and the methods by means of which, after eight years of experimentation, it was finally made possible to measure osmotic pressure with a high degree of precision. The following list of the headings of chapters will give an idea of the field covered:

I. The Cells and Their Manometer Attachments.
II. The Manometers.
III. The Regulation of Temperature.
IV. The Membranes.
V. The Weight-Normal System for Solutions.
VI. Cane Sugar. Preliminary Determinations of Osmotic Pressure.
VII. Glucose. Preliminary Determinations of Osmotic Pressure.
VIII. Cane Sugar. Final Determinations of Osmotic Pressure.
IX. Glucose. Final Determinations of Osmotic Pressure.
X. Mannite. Determinations of Osmotic Pressure.
XI. Electrolytes.
XII. Conclusion.

TERRESTRIAL MAGNETISM.

No. 175. BAUER, L. A. *Land Magnetic Observations, 1905-1910.* (*Researches of the Department of Terrestrial Magnetism.*) Quarto, IV+185 pages, 10 plates. Published 1912. Price $3.00.

No. 175. Vol. II. BAUER, L. A., and J. A. FLEMING. *Land Magnetic Observations, 1911-1913, and Reports on Special Researches.* (*Researches of the Department of Terrestrial Magnetism.*) Quarto, v+278 pages, 13 plates, 9 figs. Published 1915. Price $5.00.

These volumes contain the results of all magnetic observations made on land by the Department of Terrestrial Magnetism from the beginning of its observational work in February 1905 to the end of 1913. Descriptions of the types of instruments used are given. The discussions of the general methods of the magnetic and astronomical field work include, besides the general detail of selection and occupation of stations, specimens of field records, computations, and determinations of constants and corrections. However carefully constructed, various instruments give results differing by small, more or less constant, amounts, and in order to secure a standard of reference, extensive intercomparisons of instruments have been made at Washington, in the field, and at many magnetic observatories throughout the world; with these data it has been possible to reduce the magnetic results for the region covered in the publication to magnetic standards within an error in general on the order of the error of observation.

In Volume I intercomparisons of the provisional magnetic standards adopted with standards of 12 observatories in the northern hemisphere and 4 in the southern hemisphere, are given, as also the indirect results of observations by other organizations at seven additional magnetic observatories in the northern hemisphere; these show that the provisional standards adopted are very close to international standards, at least so far as all practical requirements of a general magnetic survey of the Earth are concerned. The corrections to these standards for the various instruments used are given in detail. The results are summarized as follows: Africa, 386 stations; Asia, 308 stations; Australasia, 10 stations; Europe, 36 stations; North America, 328 stations; South America, 111 stations; Islands of the Atlantic Ocean, 68 stations; Islands of the Pacific Ocean, 51 stations. The table of results contains for each station the geographical latitude, longitude, date of observation, observed values of magnetic declination, inclination, and horizontal intensity, the local mean times to the nearest one-tenth hour for each element, the instruments used, and the observer. The volume also contains descriptions of stations arranged under the same geographical divisions adopted in the table of results.

Volume II presents the results of all magnetic observations made on land by the Department from January 1911 to the end of 1913, and reports on some of the special researches and equipment. It describes new magnetic instruments of light and portable types, designed, constructed, and used for the field operations of the Department subsequent to the work reported in the first volume, including a combined magnetometer and dip circle and a combined magnetometer and earth inductor. The results of the extensive intercomparisons of instruments at Washington and in all parts of the world are given in detail for each instrument. The stations at which the magnetic observations were made between 1911-1913 may be summarized as follows: Africa, 202; Asia, 83; Australasia, 284; Europe, 38; North America, 48; South America, 247; Islands of the Atlantic Ocean, 16; Islands of the Indian Ocean, 14; Islands of the Pacific Ocean, 16; Antarctic Regions, 30. A table of results gives data corresponding to the table described for the first volume. Extended extracts from the Observer's reports are given, and descriptions of stations. The newly-erected research building of the Department at Washington, *viz.*, a main fireproof building containing the headquarters, laboratory, and instrument shop; a one-story non-magnetic building to serve as a standardizing magnetic observatory; and smaller accessory structures. One section of the report is devoted to the director's inspection trip in 1911 and to the observations secured at Manua, Samoa, during the total solar eclipse on April 28, 1911.

ENGINEERING.

No. 66. Goss, W. F. M. *High Steam Pressures in Locomotive Service.* Octavo, 144 pages, 12 plates, 120 text figures. Published 1907. Price $1.25.

A study based upon experimental investigations concerning the effect of changes in steam pressure upon the efficiency of steam locomotives. A basis for discussion is given in the results of 100 locomotive tests arranged in six series, a definite boiler pressure being assigned to each series. The range of pressure was varied from 120 pounds to 240 pounds per square inch. The presentation includes a description of the research and of the means employed in its advancement; a discussion of difficulties in operating a locomotive under very high steam pressures; a statement of facts concerning boiler and engine performance under different pressures, concerning machine friction, and concerning the degree of efficiency attending the performance of work at the draw-bar; and a concluding discussion with reference to the more general question of boiler pressure versus boiler capacity as a factor in economic operation. Four appendices present respectively a description of the locomotive experimented upon, methods and data derived from tests, general data concerning the weight of boilers, and a file of typical indicator-cards.

No. 127. Goss, W. F. M. *Superheated Steam in Locomotive Service.* Octavo, v+144 pages, 6 plates, 88 text figures. Published 1910. Price $1.25.

A study based upon recent foreign practice and upon experimental investigations concerning the use of superheated steam in locomotive service. In the course of this study generous attention has been given German superheating locomotives. These have been inspected when in the process of manufacture, when in service upon the road, when in shops for general repairs, and when in roundhouses for routine attention. Observations thus made prove that superheated steam may be successfully used in locomotive service without involving mechanism which is unduly complicated or difficult to maintain. The experimental investigations were conducted at the laboratory of Purdue University. They included forty-seven formal tests of an American-built locomotive. The boiler pressures employed during these tests ranged from 120 pounds to 240 pounds. The results show the relation between the degree of superheat developed and the output of power, together with such other significant data as water and fuel consumption. Heat balances covering the performance of the boiler and superheater are given for eighteen tests. The results are compared with those which are presented by Publication No. 66, entitled "High Steam Pressures in Locomotive Service," for the purpose of showing the effect of superheated steam upon the power and economy of the locomotive. Many results are presented graphically. Four appendices present a description of tests, methods, data, etc.

No. 79. Durand, W. F. *Researches on the Performance of the Screw Propeller.* Octavo, 61 pages, 85 text figures. Published 1907. Price $0.75.

An investigation into the influence on screw-propeller performance of the three chief factors: (1) pitch ratio, (2) slip ratio, (3) area ratio. Forty-two model propellers of 12-inch diameter were employed covering variation in pitch ratio from 0.9 to 2.1 and in area ratio from 0.18 to 0.72, each propeller being tested through a range of slip from 10 per cent to 40 per cent. Measurements were made permitting the determination for these model propellers of thrust, work absorbed, and efficiency. The reduced results are shown in various forms, tabular and graphical, and their application to problems of propeller design is discussed. Similar results are also given for some 47 combinations of two propellers on one shaft, comprising various arrangements of the above propellers as to relative pitch ratio, distance apart, and aspect of blades.

GEOLOGY.

No. 106. CHAMBERLIN, R. T. *Contributions to Cosmogony and the Fundamental Problems of Geology. Gases in Rocks.* Octavo, 80 pages. Published 1908. Price $0.50.

A study of gases in rocks to determine their range and distribution, the states in which gases or gas-producing substances exist in rock, with deduction as to the general relations of the gases relative to the hypothesis of a molten earth, also relative to the planetesimal hypothesis and to atmospheric supply.

No. 107. CHAMBERLIN, T. C., *et al. Contributions to Cosmogony and the Fundamental Problems of Geology. The Tidal and Other Problems.* Octavo, IV+264 pages, 19 text figures. Published 1909. Price $1.50.

This book contains the following papers, *not sold separately:*

I. The Tidal Problem:
CHAMBERLIN, T. C.—The Former Rates of the Earth's Rotation and their Bearings on its Deformation.
SLICHTER, CHARLES S.—The Rotation Period of a Heterogeneous Spheroid.
MACMILLAN, WILLIAM D.—On the Loss of Energy by Friction of the Tides.
MOULTON, F. R.—On Certain Relations Among the Possible Changes in the Motions of Mutually Attracting Spheres when disturbed by Tidal Interactions.
MOULTON, F. R.—On the Possibility of Fission of a Contracting Rotating Fluid Mass.
CHAMBERLIN, T. C.—The Bearing of Molecular Activity on Spontaneous Fission in Gaseous Spheroids.
II. LUNN, ARTHUR C.—Geophysical Theory under the Planetesimal Hypothesis.
III. STIEGLITZ, JULIUS.—Relations of Equilibrium between the Carbon Dioxide of the Atmosphere and the Calcium Sulphate, Calcium Carbonate, and Calcium Bicarbonate of Water Solutions in Contact with it.

Professor Chamberlin's paper contains a treatment of the effects of the earth's tides based upon (*a*) hypotheses as to the origin of the earth; (*b*) deductions from the tides themselves; and (*c*) geological evidences of tidal friction. The conclusions reached are that the tides of the lithosphere, hydrosphere, and atmosphere at present are not sensibly changing the rate of the earth's rotation, and that the geological evidences indicate that during geological history the rate of rotation of the earth and its shape have been approximately as they are at present.

Professor Slichter gives, in tabular form, the polar and equatorial radii, the ellipticity, the polar and equatorial attractions, the latitude of mean radius, the equatorial contraction, and the meridional elongation for various rates of rotation.

The rate of change of rotation of the earth from the rate of degradation of energy in the ocean tides is computed by Professor MacMillan. The result reached, after making liberal assumptions as to the magnitudes of the tides, is that they lengthen the day one second in 500,000 years.

The first paper of Professor Moulton starts with the present earth-moon system and, by considering particularly the relations of energy and moment of momentum, traces the members of the system back to their closest possible proximity. It is found that at their closest possible approach their surfaces were more than 4,000 miles apart, and it is inferred that the moon did not originate by fission from the earth. From a consideration of the secular acceleration of the moon's motion it is found that the day is now changing at the rate of one second in 13,000,000 years

Professor Moulton's second paper starts with the original united hypothetical earth-moon mass and considers the question of its fission. It is found that the mass could not suffer fission under contraction until its density became many times that at present. This paper, together with his preceding paper, leads to the conclusion that the moon has not originated by fission from the earth.

Professor Chamberlin, in his second paper, considers the bearing of molecular activity on mass fission, and concludes that it keeps the equilibrium from becoming disturbed to such an extent that the separation of large masses is possible.

Professor Lunn's work is mainly a quantitative study of that portion of the earth's internal energy which may have been derived from the mechanical energy of a system of planetesimals. The computations are made for the Laplacian law of density, and then the influences of certain secondary hypotheses are considered.

Professor Stieglitz makes a study of the conditions for precipitation and deposition of calcium sulphate, calcium carbonate, and calcium bicarbonate in the presence of atmospheric carbon dioxide.

No. 87. *The California Earthquake of April 18, 1906. Report of the State Earthquake Investigation Commission,* ANDREW C. LAWSON, Chairman. Quarto, two volumes and atlas.

Vol. 1 (in 2 parts). *Report of the Commission.* Published 1908.
Part I, pages XVIII+254, plates 1-98, text figures 1-54.
Part II, pages 255-451, plates 99-146, text figures 55-69.
Atlas contains 25 maps relating to volume 1 and 15 sheets of seismograms relating to volume 2.
} $17.00
Vol. 2. *Mechanics of the Earthquake.* By H. F. REID. 200 pages, 2 plates, 62 text figures. Published 1910. Price $2.00.

This is the report of the State Earthquake Investigation Commission appointed by the Governor of California to study the earthquake of April 18, 1906. The fault where the earthquake originated is a part of a larger physiographic feature known as the San Andreas rift. This rift and the geology of the coast system of mountains are carefully described in the first volume, which is mainly descriptive. Then follow detailed accounts of the displacements along all parts of the fault and descriptions of the effect and intensity of the shock in all parts of California and the neighboring States, where it was felt. All the phenomena observed are described, including the visible undulations of the ground, the formation of cracks, fissures, landslides, etc. The permanent displacements of the ground, as determined by geodetic measurements, are given, and the positions of certain monuments erected for the purpose of determining future slips on the fault are recorded.

The second volume, on the mechanics of the earthquake, contains a theoretical discussion of the phenomena described in the first volume. It traces the forces required to cause the rupture at the fault to drags applied from below, and points out that the rupture was necessarily preceded by a relative displacement of regions on opposite sides of the fault, which suggests a method of anticipating certain earthquakes. The records obtained by seismographs in all parts of the world are given and discussed. A very complete mathematical theory of seismographs is given.

No. 57. WASHINGTON, H. S. *The Roman Comagmatic Region.* Octavo, VI+199 pages, 3 text figures. Published 1906. Price $1.00.

A petrological discussion of the main line of Italian volcanoes, from Lake Bolsena to Vesuvius. Complete and detailed, largely quantitative, descriptions, and numerous new chemical analyses of the various rock types are given, and their mutual relations and the general petrological characters of the petrographic province are discussed at length, the basis of the discussion being largely chemical. The descriptions and treatment are in accordance with the Quantitative Classification of Igneous Rocks, of the methods and terminology of which this work serves as an example, though the ordinary rock names are also used.

No. 46. ADAMS, F. D., and E. J. COKER. *An Investigation into the Elastic Constants of Rocks, more especially with reference to Cubic Compressibility.* Octavo, 69 pages, 16 plates, 26 figures. Published 1906. Price $1.75.

In the report on this investigation the amount of cubic compressibility which rocks undergo when submitted to pressure before they begin to flow, or under conditions when they are unable to flow, is determined. In arriving at these results the elastic constants of the rocks were investigated. Fifteen typical rocks, representing the chief types of acid and basic plutonic rocks forming the deeper portions of the earth's crust, were studied, together with certain sedimentary and metamorphic rocks. A comparative study was also made of the cubic compressibility and elastic constants of plate glass.

No. 26. Pumpelly, Raphael, W. M. Davis, R. W. Pumpelly, and Ellsworth Huntington. *Explorations in Turkestan, with an Account of the Basin of Eastern Persia and Sistan. Expedition of 1903.* Quarto, xii+324 pages, 6 plates, 174 text figures. Published 1905. Price $4.00.

Besides the archeological and physico-geographical report by Professor Pumpelly, on his reconnaissance in Turkestan, Publication No. 26 contains a report of nearly 100 quarto pages by Prof. William M. Davis, of Harvard University, mainly consisting of a geological study of Turkestan. Mr. R. W. Pumpelly contributes physiographic observations between the Syr Darya and Kara Kul, on the Pamir, and Mr. Ellsworth Huntington, of Yale University, contributes two papers, entitled, "A Geological and Physiographic Reconnaissance in Central Turkestan" and "The Basin of Eastern Persia and Sistan."

No. 54. Willis, Bailey, Charles D. Walcott, and others. *Research in China.* In three volumes and atlas.

Vol. I in two parts. Published 1907. Price $8.00.
Part I. Descriptive Topography and Geology; by Bailey Willis, Eliot Blackwelder, and R. H. Sargent. Quarto, pages xiv+353+xvi, plates i-li, 65 text figures.
Part II. Petrography and Zoology; by Eliot Blackwelder. Syllabary for the Transcription of Chinese Sounds; by Friedrich Hirth. Quarto, pages vi+355-528+xvii-xxiv, plates lii-lxiii (including 6 plates of birds colored to life).
Atlas. By Bailey Willis, Eliot Blackwelder, and R. H. Sargent. Folio, 42 maps and 21 other illustrations. Published 1906. Price $7.00.
Vol. II. Systematic Geology. By Bailey Willis. Quarto, v+133+v pages, 8 plates. Published 1907. Price $2.00.
Vol. III. Paleontology. Quarto, 375 pages. Published 1913. Price $5.00.
The Cambrian Faunas of China, 24 plates, 9 figures; by Charles D. Walcott.
A Report on the Ordovician Fossils collected by the Carnegie Institution Expedition to Eastern Asia, 2 plates; by Stuart Weller.
Report upon Upper Paleozoic Fossils from China collected by the Carnegie Institution Expedition, 3 plates; by George H. Girty.

Volume I, Part I, contains observations relating to the geology of northeastern, northern, and central China (Shan-tung, Chi-li, Shan-si, and Shen-si). The treatment is primarily by districts, and under each district the terranes observed are described in order from older to younger. The nature and succession of strata, the fossils, and the structure of each terrane are discussed. The terranes observed may be enumerated as follows: Pre-Cambrian, Cambrian, Ordovician, Devono-Silurian (in Central China only), Carboniferous, Permian (?), Jurassic, and Quaternary. The principal contributions to knowledge relate to the Pre-Cambrian, the stratigraphy and fossils of the Cambrian and the history of the Quaternary. The last named comprises an analysis of the mountain forms in terms of uplift and erosion and a discussion of the loess. A unique feature is the account of an early Cambrian tillite or glacial till, which underlies the Cambrian limestone of the Yang-tzi valley. The volume is profusely illustrated with photographs of the scenery of the mountain districts of Chi-li, Shan-si (the land of the loess), and Shen-si.

The atlas contains 2 route maps, 20 topographic maps, and 20 identical geologic maps. The topographic maps represent the features along and adjacent to the route on a scale of 1 : 125000, with 100-foot contours. They are based on plane-table surveys and the forms of the land were sketched expressively in contours on the spot.

Vol. I, Part II, includes three special reports which are subsidiary to the general treatment of the geological observations in Part I of the same volume.

The first and largest section contains a description of the varieties of igneous, metamorphic, and sedimentary rocks collected by the expedition in China. All of these specimens come from northern China, the majority of them being from Shan-tung, western Chi-li, eastern Shan-si, and southern Shen-si. The collection comprises typical representatives of the geological systems from Archean to Mesozoic. Of special importance are the description and interpretation of the varied oolitic and conglomeratic limestones found in the Cambrian terrane.

The second section, dealing with zoological observations, includes an annotated list of the amphibians, reptiles, and birds observed. About 130 species of birds are noted and of these 6 of the least known are illustrated by beautiful colored plates.

The last section contains a syllabary of Chinese sounds, prepared by Professor Hirth, of Columbia University. The orthography recommended by the author is

compared in tabular arrangement with that of Williams and Wade, and all are referred to the corresponding Chinese ideographs.

Volume II treats of the same material as Volume I, but from the standpoint of systematic continental history. Repetition has been avoided so far as is consistent with the general subject. The subject-matter of this volume is classified primarily according to geologic eras of periods, and secondarily by broad areas, of which China proper is the central region. Each chapter treats of the geographic condition of southeastern Asia during a particular age, and the successive chapters trace the sequence of changes from age to age. Only the great events of continental history are distinguishable on the basis of existing knowledge, but they suffice to show that the present continent is an aggregation of land masses which, from time to time, have been forced into union with one another. This study of Asia has been carried on with comparative studies of North America and Europe, and has led to theoretical views regarding continental structure and development which have a broad application. They are briefly stated in a closing chapter.

Volume III contains the description and illustration of the Paleozoic fossils collected by the expedition, of which the greater portion are Cambrian in age. The section devoted to the Cambrian, written by Dr. Walcott, includes the description and correlation of fossils collected by Prof. J. P. Iddings on Tschang-hsing-tau Island, Manchuria, and treats of the development of our knowledge concerning the geology and paleontology of the Cambrian formations of China. Each of the localities is described in detail, with lists of included species and notes indicating their position in the general lists of species accompanying the discussion of the stratigraphy in Volume I; the vertical and cross sections given in that volume are redrawn, showing the locality numbers in their proper positions; and the faunal horizons are correlated with each other and, so far as possible, with those of other countries. The volume also contains an important report by Prof. Stuart Weller on the Ordovician fossils collected in Eastern Asia in 1903-4, accompanied by two plates. These fossils include two collections, one from the province of Shan-tung and the other from the extreme eastern portion of the province of Ssï-ch'uan.

Dr. George H. Girty has contributed to the volume a report on Upper Paleozoic fossils collected in China 1903-4, together with three plates. The specimens were obtained from localities quite widely separated and Dr. Girty's discussion of the collections is a valuable contribution to the geologic history of the region.

No. 192. Huntington, Ellsworth, with contributions by Charles Schuchert, A. E. Douglass, and Charles J. Kullmer. *The Climatic Factor, as Illustrated in Arid America.* Quarto. (For full description, see page 109.)

Other papers relating to geology are the publications of the Geophysical Laboratory, Nos. 31, 157, and 158. For descriptions see under Chemistry and Physics, page 38.

No. 55. CASE, E. C. *A Revision of the Pelycosauria of North America.* Quarto, 176 pages, 35 plates, 73 text figures. Published 1907. Price $3.00.

This monograph gives a revision and morphological description of the North American reptiles of the Permian and Upper Carboniferous, especially those from the Red Beds of northern Texas, together with the history of the group. The taxonomy and synonymy are considered with some detail; the location of all types and the original descriptions are given. This is followed by a revised description of all types, by the descriptions of new forms, and a discussion of the biological and geological relations of the group. A bibliography of all important papers is given which, in connection with Hay's Catalogue of the Vertebrata of North America, furnishes a complete bibliography of the group up to the date of publication.

No. 145. CASE, E. C. *A Revision of the Cotylosauria of North America.* Quarto, 122 pages, 14 plates, 52 text figures. Published 1911. Price $3.00.

This monograph, which is the second in the series dealing with the vertebrate fauna of the Permian or Permo-Carboniferous period in North America, gives a revision and morphological description of the group of primitive reptiles called Cotylosauria. The same general plan is followed in this work as in the previous volume on the Pelycosauria. The types are redescribed and the original descriptions quoted. Much new material is also described and a scheme of classification is proposed which reconciles all the facts now available. Several types which have been found to be indeterminable are so listed. The location and museum number of each type and characteristic specimen are given. A morphological description of each form follows the systematic portion with a discussion of probable relationships and habits. The bibliography includes all papers referred to in the text and all which have been published since the appearance of Hay's Bibliography and Catalogue.

No. 146. CASE, E. C. *A Revision of the Amphibia and Pisces of the Permian of North America.* Quarto, 184 pages, 32 plates, 56 text figures. Published 1911. Price $4.00.

This is the third monograph of the series on the vertebrate life of the Permian or Permo-Carboniferous period in North America. The method of treatment is the same as in the two previous monographs. A full systematic revision is given for both the amphibians and fishes, followed by a morphological description of each form. The location and museum number of each type and characteristic specimen are recorded. The bibliography is complete, in connection with Hay's "Catalogue and Bibliography of the Vertebrata of North America." The portion upon the fishes is the independent work of Dr. Hussakof, except the part included in the history of work upon the amphibians and fishes. A short article by Dr. E. H. Sellards describes two new cockroaches from the beds in Texas.

No. 181. CASE, E. C., S. W. WILLISTON, and M. G. MEHL. *The Permo-Carboniferous Vertebrates from New Mexico.* Quarto, v+81 pages, 1 plate, 51 figures. Published 1913. Price $2.00.

This is a supplementary volume to those published by E. C. Case on the Permo-Carboniferous vertebrates of North America. It contains an account of the exploration of the Permo-Carboniferous beds of El Cobre Canyon, near Abiquiu, and those on the Arroyo de Agua, both in Rio Arriba County, New Mexico. Fossils of this age were first discovered in New Mexico by James Baldwin over thirty years ago, and specimens found their way into the hands of both Cope and Marsh, who described imperfect material. The result of this exploration was the discovery of a large quantity of new material, including some exceptionally perfect specimens. The monograph contains descriptions of new material, corrections of synonymy and of errors of interpretation, and references to all material described elsewhere. The two senior authors collaborated in order to avoid all possible errors and future discussion and are jointly responsible for all statements made by them. Dr. Mehl's part consists in the description of a single specimen.

No. 207. Case, E. C. *The Permo-Carboniferous Red Beds of North America and Their Vertebrate Fauna.* Quarto, 176 pages, 24 plates, 50 text figures. Published 1915. Price $4.00.

This is the fifth monograph of the series dealing with the Permian Vertebrates of the Permo-Carboniferous of North America. The first four deal with the taxonomy and the morphology of the different groups of vertebrates. The present describes: (1) The stratigraphy of the different beds in which the fossils occur; the conditions under which the beds were deposited; the climatology of the time interpreted from the deposits; all other recognized inorganic factors constituting the inorganic environment of the fauna. (2) The habits and inter-relations of the animals as interpreted from their structure; the food habits as interpreted from the teeth and other parts; the possible food supply as a check on the assumed food habits. (3) The appearance of the forms, so far as known, with restorations of the better-known species. (4) The origin, development, and extinction, or disappearance, of the fauna. (5) The surface of North America in Permo-Carboniferous time; the possible land connections of the continent with other continents in reference to the possible migrations of the fauna. A synoptic table gives the geographical and geological distribution of the various forms and the author's idea of the proper classification. The whole monograph is a summary of our knowledge of the fauna and an attempt to study the evolution of the group from its inception to its extinction or final disappearance from the continent, in the light of all recognized controlling factors, organic and inorganic. The relations of the fauna to that of other continents is not treated in detail as it is planned to consider this phase of the matter in a continuation of the work.

No. 75. Hay, Oliver P. *The Fossil Turtles of North America.* Quarto, iv+568 pages, 113 plates, 704 text figures. Published 1908. Price $9.00.

This work has for its purpose the careful description of all the species of fossil turtles of North America that were known to exist at the time of publication. In all 266 species are described and, with few exceptions, figures are given of all of these. Of the 266 species 76 are regarded as hitherto undescribed. The classification of the order is discussed and the families and genera are carefully defined. Before entering on the consideration of the fossil forms the osteology of most of the living families is elucidated. The modifications undergone by the turtles since their earliest appearance are discussed, as well as the derivation of the order and its various families. There is a chapter on the geographical distribution of the living turtles, illustrated by 8 maps. Two tables present the geological distribution of the North American extinct species. This work is of interest to all students of these reptiles, as many of the genera here described still exist.

No. 34. Wieland, G. R. *American Fossil Cycads.* Quarto.

Vol. I. Structure. viii+296 pages, 51 plates, 141 text figures. Published 1906. Price $6.25

Vol. II. Taxonomy. In press.

In volume I a record is made of the discoveries and collections of silicified cycads. Some of the more important finds noted were made by the author. These include the most remarkable of the branched forms. The various conditions of fossilization and methods of treatment, including the cutting of large thin sections, are taken up. The foliage of the Cycadeoids is determined from the young crowns of partially emergent fronds and compared with that of the existing cycads, some new facts about the latter being brought out. The ovulate fructification is described in much detail, and the discovery of the bisporangiate flower buds is set forth on the basis of completely illustrated serial sections. The subject of young fructifications is dealt with in preliminary form. There is thus given a redintegration of the long problematic Cycadeoid type. This part of the work affords a key to the study of many hitherto scantily known fossil casts and imprints of Cycadaceous affinity. The closing chapters are devoted to a thoroughly illustrated comparative study of the habitus and structure of the existing cycads and to a new theory of angiosperm descent from hypothetic types little remote from the early Mesozoic Cycadeoids.

In volume II the structure of the Cycadeoids is taken up from the viewpoint of classification and nomenclature. Trunk structure is further considered on the basis of large polished transverse and longitudinal, and also thin sections. Notes are given on nearly all the more important American species, and the necessary comparisons with European forms are drawn. The aim is to give in clear and usable form the present status of Cycadeoid study. Incidentally many new details of both structural and general biologic interest are illustrated. In particular the remarkable monocarpic species *Cycadeoidea dartoni* is described. As in volume I extended comparison with existing cycads was made, so in volume II a well-illustrated account of the related Mesozoic Cycadophytan stem, leaf, and fruit imprints, and casts is appended. This in large part rests on the author's own discoveries in the Liassic of Mexico. A fuller account of the seeds is given, and new theories of seed and floral constitution are discussed. The descent of the angiosperms is further considered. The two volumes therefore constitute a treatise on the Cycadeoids setting forth all the main features of the group thus far discovered. Both volumes are profusely illustrated and contain the necessary bibliographies.

No. 238. Moodie, Roy L. *The Coal Measures Amphibia of North America.* Quarto. In press.

A complete account of the anatomy, distribution, classification, and relationships of the oldest known land vertebrates of North America is given so far as may be determined from the material which has been discovered. It is accompanied by a bibliography of 645 titles, which are citations to all the studies made to December 1915, on the fossil Amphibia of the world. Especial emphasis is laid on the anatomical facts. Plates and text figures show the osteology, the lateral-line system, the dermal covering, the alimentary canal, and such other features as are possible of ascertainment from the fragmentary material. The history of the classification of the fossil Amphibia is given, together with an account of the discovery of the land vertebrates in the Coal Measures of North America. Discussions of the manner of occurrence and the geological and geographical distribution are accompanied by maps and photographs. A large share of the volume is devoted to careful description and classification of the 90 species which are now known to occur in the Coal Measures of North America, with figures, reconstructions, location of type material, synonymy, and references to the original descriptions.

ARCHEOLOGY.

No. 26. PUMPELLY, RAPHAEL, W. M. DAVIS, R. W. PUMPELLY, and ELLSWORTH HUNTINGTON. *Explorations in Turkestan, with an Account of the Basin of Eastern Persia and Sistan. Expedition of 1903.* Quarto. (See page 49 for description.)

No. 73. PUMPELLY, RAPHAEL, *et al. Explorations in Turkestan, Expedition of 1904. Prehistoric Civilizations of Anau.* In two volumes. Quarto, XXXV+494+X pages, 97 plates, 548 figures. Published 1908. Price $10.00.

Vol. 1. Reports by RAPHAEL PUMPELLY and HUBERT SCHMIDT, with contributions by HOMER KIDDER, ELLSWORTH HUNTINGTON, and F. A. GOOCH. Pages XXXV+1-240+VI, plates 1-60, and text figures 1-430.

Vol. 2. Reports of R. W. PUMPELLY and J. U. DUERST, with contributions by G. SERGI, TH. MOLLISON, H. C. SCHELLENBERG, and LANGDON WARNER. Pages X+241-494+X, plates 61-97, figures 431-548.

The object of the exploration was to search for evidence for or against the Central Asiatic origin of early cultures, with especial reference to the hypothesis of a so-called Asiatic Aryan home. The volume of the Reconnaissance Expedition of 1903 contains the results of the separate expeditions of Prof. W. M. Davis, of Harvard University; of Mr. Ellsworth Huntington, and of Professor Pumpelly and Mr. R. W. Pumpelly. These results are chiefly:

1. The corroboration and extension of the evidence of an extensive Glacial and post-Glacial inland sea.

2. The independent determination of at least three Glacial and two inter-Glacial phases of the Glacial Period in the Tien Shan and on the Pamir.

3. The observation of a vast number of ruined sites of all ages, some of which were evidently of very remote age.

The two volumes of 1904 treat of the archeological and physiographic results of the Second Expedition, with especial reference to the excavations at Anau and incidentally at Merv. The following reports are presented:

Ancient Anau and the Oasis-World, and General Discussion of Results, XXXV+80 pages, 6 plates, 21 figures. By Raphael Pumpelly.
Archeological Excavations in Anau and Old Merv. By Hubert Schmidt. 127 pages, 50 plates, 408 figures.
Note on the Occurrence of Glazed Ware at Afrosiab, and of Large Jars at Ghiaur Kala. By Homer H. Kidder. 4 pages, 2 figures.
Description of Kurgans of the Merv Oasis. By Ellsworth Huntington. 13 pp., 4 pl.
Chemical Analyses of Metallic Implements from Anau. By F. A. Gooch.
Physiography of Central-Asian Deserts and Oases. By R. Welles Pumpelly.
Animal Remains from the Excavations in Anau, and the Horse of Anau in its Relation to the Races of Domestic Horses. By J. Ulrich Duerst. 100 pages, 20 plates.
Description of some Skulls from the North Kurgan, Anau. By G. Sergi.
Some Human Remains found in the North Kurgan, Anau. By Th. Mollison.
Wheat and Barley from the North Kurgan, Anau. By H. C. Schellenberg.
Stone Implements and Skeletons excavated in Anau. By Langdon Warner.

In the expedition of 1904 two sites on the Oasis of Anau were excavated, exposing four successive civilizations—Anau I, II, III, IV, extending with breaks from 8000 B. C. to the beginning of our era, and aggregating over 130 feet of culture strata and a later city of the period of known history. The archeologist, Dr. Hubert Schmidt, of the Royal Museum für Völkerkunde of Berlin, describes the excavations and gives a critical description of the successive potteries and other finds. Prof. J. Ulrich Duerst, of the University of Berne, gives an extended comparative anatomical study of the abundant animal remains, collected foot by foot from the lowest culture strata upward, of the two oldest civilizations. In these he finds the beginning of domestication and the differentiation of breeds and origin of some prehistoric European breeds. He also contributes a chapter on the desert horse of Anau in its relation to the varieties of domestic horses.

In the opening chapters of Volume 1 (1904) Professor Pumpelly, after tracing the evolution of the environment that conditioned the prehistoric civilizations of

Anau, reviews the characteristics of the civilizations and analyzes the results of his own and his collaborators' investigations. By physiographic methods there were obtained, through shafts in the oasis formation, a determination of the rate of alluvial growth relatively to that of the accumulation of the débris of civilization and evidence of three climatic cycles, paralleling the cultures, as well as their relation to the rise and fall of these. The rate of accumulation of débris of civilization is found subject to a fixed law, and the stratigraphic rate is converted into a time scale which is confirmed by the author's study of datable Egyptian village mounds. Thus, and partly from internal evidence, is obtained the dating of the beginning of the cultures Anau I, II, III, IV (8000, 6000, 5000, 4000 B. C.) and 3000 to 4000 years as the duration of a climatic cycle. The civilizations Anau I, II were wholly Central Asian; the people isolated from Europe and Africa, at least since an inter-Glacial period, by the inland sea of the Glacial epoch, were forced by increasing aridity on to the oases and to the evolution of agriculture. The dolichocephalic founders of Anau I and II were by long inheritance town-building cultivators of wheat and barley who later began the domestication and breeding of animals—the criteria of civilization.

Toward the end of Anau III (5000 to 3000 B. C.) appears external (Chaldean) influence and culture.

Anau I and II had slight knowledge of copper. Anau III covers the developed copper age, but ends before the use of bronze.

There was a long gap between copper culture (III) and iron (IV).

The agricultural preceded the nomadic shepherd stage.

The arid extremes caused the great migrations.

The climatic reaction following the Glacial period began the evolution of organized civilization.

Domestic animals and elements of agriculture of dolichocephalic Anau-li were brought to Europe in the late stone age by brachycephalic Asiatic immigrants.

The relation of Anau cultures I and II to early Babylonia and Susa are discussed.

No. 53. Müller, W. Max. *Egyptological Researches.*
Vol. 1. Results of a Journey in 1904. Quarto, 62 pages, 106 plates. Published 1906. Price $2.75.
Vol. 2. Results of a Journey in 1906. Quarto, v+188 pages, 47 plates. 68 text figures. Published 1910. Price $9.00.

Volume 1 records the results of an expedition by the author in 1904, having as its object a study of the monuments recording the relations of ancient Egypt to foreign countries, especially to Asia and Europe—monuments which are mostly direct contributions to Biblical studies and in many ways elucidate the history of the whole world. Professor Müller sought especially to secure final, or at least better, copies of the most important "known" texts rather than to obtain "new" material.

Volume 2 is a continuation of the above and records the author's researches in 1906.

No. 100. Ward, William Hayes. *The Seal Cylinders of Western Asia.* Quarto, xxix+428 pages, 1,500 text figures. Published 1910. Price $7.50.

These seal cylinders were of the size of a large or small spool, purely cylindrical or with the surface concave and in the latest Persian period convex and barrel-shaped. In the earliest period they were made of the central hard core of a conch shell from the Persian Gulf; afterwards of serpentine or lapis-lazuli; then hard stones, quartz crystal, chalcedony, or carnelian. Every owner of property had to have one of the cylinders. The engravings on them were usually figures of the gods worshiped by the owners, or scenes of agriculture, war, or the chase. Later the owner's name would be added in cuneiform characters, with the name of his father and that of his favorite god. This work opens with an introduction describing the materials, the tools, the uses of the cylinders, and the principles of classification, and it closes with a discussion of religions and sacrifices, lists with figures of the gods and their symbols, and a conclusion as to the source of the earliest culture, which seems to have been in Elam, just east of Babylonia, on the Persian Gulf. The main body of the

work is devoted to the study of these seals as classified by nationality, period, and subject. Almost every page has several illustrations, so that the student of history, civilization, and art has here a body of material and conclusions not hitherto accessible to scholars.

The present volume consists of about 450 quarto pages with over 1,500 drawings, and may be described as an investigation of the earliest art of Babylonia and its later ramifications, showing the sources of that stream of culture which finally overflowed in Greek art and civilization. From that period of perhaps 4000 B. C., long before the use of iron, if not before that of bronze, the course of art and culture and religion is followed as it spreads over Persia on the east and as far as the Mediterranean Sea and Cyprus on the west, including Assyria, the Hittite Empire of Asia Minor, Syria, and Phœnicia. Thus the investigation reaches down to about 600 B. C., when the seal cylinder gave way to seals of other sorts, owing to the growing disuse of clay tablets for writing and the substitution of the simpler cone seal and scaraboid in place of the cylinder.

No. 108. Van Deman, Esther B. *The Atrium Vestæ.* Octavo, xii+47 pages, 17 plates. Published 1909. Price $1.50.

This is a careful study of one of the many interesting problems which arise in the study of Roman topography and Roman architecture. The magnificent House of the Vestals was not the work of one period, but was enlarged and beautified during successive epochs, the later builders doing their work in such a way as to fit it, as far as possible, into that of their predecessors, thus producing the impression of a uniform structure. In this monograph the House of the Vestals is considered not as an isolated problem, but in connection with a thorough study of Roman brickwork, and the author has reconstructed the history of the building for the first and second centuries A. D.

No. 200. W. H. R. Rivers, A. E. Jenks, and S. G. Morley. *Reports upon the Present Condition and Future Needs of the Science of Anthropology.* Quarto, 91 pages, 14 plates. Published 1913. Price $2.00.

The above volume consists of three elaborate reports upon the present status of the science of Anthropology: one concerning Anthropological Research outside America, by Dr. W. H. R. Rivers, of Cambridge University; one on the status of this science in the western hemisphere and the Pacific Islands, by Dr. Albert E. Jenks, of the University of Minnesota; and one on the possibilities of archeological research at the ruins of Chichen Itza, Yucatan, by Mr. Sylvanus G. Morley.

No. 219. Morley, Sylvanus Griswold. *The Maya Inscriptions. The Inscriptions of Copan, Honduras.* Quarto, 32 plates. In press.

This volume deals with the hieroglyphic inscriptions of the ancient Maya civilization of southern Mexico and northern Central America, and is especially devoted to a consideration of the inscriptions of Copan, Honduras, one of the largest and oldest centers of the Old Empire. This city flourished during the first five centuries of the Christian Era and is particularly noteworthy for the large number of its hieroglyphic monuments. The texts are presented upon a variety of media: stelæ, altars, door-jambs, façades, steps, and stairways. They vary in length from 2 glyphs to over 2,000. In fact the longest inscription in the Maya writing is found here—the Hieroglyphic Stairway on the western slope of Mound 26, which contains upwards of 2,500 glyphs. Of the 81 texts under observation, which include all now known, 22 were found to belong to The Archaic Period (*i. e.*, from the earliest times down to 9.10.0.0.0, approximately to 360 A.D.); 17 to The Middle Period (*i. e.*, from 9.10.0.0.0 to 9.15.0.0.0, approximately 360 to 460 A.D.); and 42 to The Great Period (*i.e.*, from 9.15.0.0.0 to 10.2.0.0.0, approximately 460 to 600 A.D.). There are many drawings and photographs of heretofore unknown or undescribed inscriptions, and these include a large amount of "new material" here made accessible to students of the Maya hieroglyphic writing for the first time.

The work closes with a number of appendices, including lists of the monuments upon which the investigation was based, arranged according to their chronological sequence; lists of all known contemporaneous monuments from other sites; correlation tables; distribution maps and diagrams and a complete bibliography of the site. In short this monograph presents an exhaustive study of the Copan inscriptions based upon a first hand examination of the originals.

For other works relating to Archeology, see No. 54, on page 49, and No. 192, on page 109.

HISTORY.

No. 13. Adams, E. D. *Influence of Grenville on Pitt's Foreign Policy, 1787-1798.* Octavo, 79 pages. Published 1904. Price $0.50.

This paper endeavors by means of published correspondence, especially the Dropmore Papers, to answer the important question how far the foreign policy of England during the prime ministry of William Pitt the younger, and especially during the period when his cousin Lord Grenville was Secretary of State for Foreign Affairs, was devised and controlled by Pitt, and how far his management of foreign affairs during that critical period was influenced by Grenville.

No. 14. Van Tyne, C. H., and W. G. Leland. *Guide to the Archives of the Government of the United States in Washington.* Octavo, xiii+215 pp. Published 1904. (Out of print. See publication No. 92.)

No. 92. Van Tyne, C. H., and W. G. Leland. *Guide to the Archives of the Government of the United States in Washington. Revised Edition.* Octavo, xiii+327 pages. Published 1907. Price $1.25.

The first historical enterprise of the Carnegie Institution was the making of an inventory, more largely from an historical than from an administrative point of view, of the governmental archives in Washington. The need of such an inventory was peculiarly pressing on account of the want of concentration of archive material in our national capital. Far from having effected such concentration as has been brought about by the English government in its Public Record Office, our practice has been, except in the case of the War Department, to leave the custody and arrangement of the papers of each subdivision of a department to its administrative chief, so that the archives of the government consist of at least a hundred separate deposits, classified and managed in different ways and in different places. Messrs. Van Tyne and Leland brought out in 1904 a volume of 215 pages, indicated under No. 14 above. This volume is now out of print. A new edition being requisite, Mr. Leland spent a year in revision and amplification, this work resulting in Publication No. 92, which describes the historical papers accumulated by each office of the government, including the two Houses of Congress and the Library of Congress.

No. 22. McLaughlin, A. C. *Report on the Diplomatic Archives of the Department of State, 1789-1840.* Octavo, 73 pages. Published 1904. (Out of print.) Price $0.25.

No. 22. McLaughlin, A. C. *Diplomatic Archives of Department of State, 1789-1840.* Revised Edition. Octavo, 73 pages. Published 1906. Price $0.25.

This report is confined to the period from 1789 to 1840, and discusses the various materials in the archives named; how largely this material has already been printed in the *American State Papers, Foreign Affairs;* the character of the various materials, and their value to historical workers. Some specimen letters are printed.

No. 38. McLaughlin, A. C., W. A. Slade, and E. D. Lewis. *Writings on American History, 1903.* Octavo, xiv+172 pages. Published 1905. Price $1.00.

This is a bibliography of books, pamphlets, and articles on United States history published during the year 1903. The endeavor is also made to include important publications relating to Canada and Latin America. The material is arranged in a methodical order and extends to 3,591 items. An elaborate alphabetical index is added. This publication was not continued by the Carnegie Institution.

No. 137. Allison, W. H. *Inventory of Unpublished Material for American Religious History in Protestant Church Archives and Other Repositories.* Octavo, vii+254 pages. Published 1911. Price $1.50.

American religious history, if dealt with not in a denominational spirit but on broad lines, is quite as important a part of the historian's concern as any other aspect of the social history of the United States. Of the unprinted material for it, however, a large part has escaped the knowledge of workers because of being kept in

denominational or local repositories which have not had the same means of making their treasures widely known as are possessed by governmental establishments and public libraries. Therefore Mr. Allison was commissioned to make a personal examination of the manuscript materials for American religious history in the accessible archives of Protestant denominations, of their missionary societies, and in the libraries of their theological seminaries, colleges, and historical societies. The book lists, in alphabetical order by States and cities, the voluminous but scattered materials thus found. An elaborate index brings the material conveniently together.

No. 148. PARKER, D. W. *Calendar of Papers in Washington Archives relating to the Territories of the United States.* Octavo, 476 pages. Published 1911. Price $3.00.

Two-thirds of the States have been Territories. Therefore, the materials for their earlier history are in large degree to be found in one or another of the governmental archives in Washington. Much effort is expended by workers in these States in the endeavor to find materials of this class. The difficulties are made very great by the extraordinarily dispersed condition of the records of the government, which has not one archive, but at least a hundred; and the distribution of papers among them is often casual or arbitrary, and in all cases it is hard to follow. Mr. Parker, after spending many months in listing in a wide variety of governmental archives in Washington the papers relating to the history of the several territories, more especially their constitutional, political, and administrative history, has brought the data together into a form classified first by territories, and chronologically under each territory. This mode of classification, together with a full index, makes available a vast amount of material, most of which was hitherto entirely unknown to investigators. The number of items in the Calendar is nearly ten thousand.

No. 172. PARKER, D. W. *Guide to the Materials for United States History in Canadian Archives.* Octavo, 339 pages. Published 1913. Price $2.00.

The archives of the Dominion of Canada in Ottawa are made up of two great masses of material. One is a great collection of transcripts from the English and French archives. Of these the Dominion Government published calendars, and Mr. Parker could therefore give them a summary treatment, the more so because the originals from which they are copied will be described in the Institution's books on the London and Paris archives. The other mass comprises what may be called indigenous Canadian materials, derived from the offices of the Governor-General, the Secretary of State, and the various ministries, and rich in materials for the history of the United States, especially in the period since 1791. Besides a careful descriptive list of these, Mr. Parker has included in the book similar accounts of the materials for United States history in the provincial archives of Nova Scotia at Halifax, in those of New Brunswick at Fredericton, and in those of the Province of Ontario at Toronto. Full accounts and lists of materials of similar bearing in the civil archives of the Province of Quebec and in the ecclesiastical archives of the archbishopric there, and briefer descriptions of the archives of Newfoundland, British Columbia, and other western provinces have been added by other hands.

No. 90. ANDREWS, CHARLES M., and FRANCES G. DAVENPORT. *Guide to the Manuscript Materials for the History of the United States to 1783, in the British Museum, in Minor London Archives, and in Libraries of Oxford and Cambridge.* Octavo, XIV+499 pages. Published 1908. Price $2.00.

The chief masses of material in London for the history of the United States are those in the Public Record Office. A volume relating to these, upon which Professor Andrews has expended a large amount of time and labor, would naturally have had precedence over this present work; but its publication has had to be deferred on account of the large amount of reclassification which the Public Record Office has resolved upon in respect to the Colonial Office papers and other portions of the whole. Accordingly the present volume, though naturally supplementary, has been brought out first in order. Professor Andrews has furnished an itemized list, with proper explanations and comments, of all those papers in the library of the British Museum which relate to the history before 1783 of the United States and all other British portions of North America. This he has followed

with an account of the materials in the Privy Council Office. Miss Davenport has furnished detailed statements of the materials for American history preserved in the archives of the House of Lords, in the library of the Archbishop of Canterbury at Lambeth, in that of the Bishop of London at Fulham, and in other archives, public and semi-public, civil and ecclesiastical, in London. Professor Andrews concludes the volume with an itemized list of the American papers in the Bodleian Library and in other libraries of Oxford and Cambridge. The volume is minutely indexed.

No. 90A. Andrews, Charles M. *Guide to the Materials for American History, to 1783, in the Public Record Office of Great Britain.* Octavo, 2 vols.
Vol. I. The State Papers, xi+346 pages. Published 1912. Price $2.50.
Vol. II. Departmental and Miscellaneous Papers, viii+427 pages. Published 1914. Price $3.00.

Of all archives in Europe the Public Record Office in London contains by far the greatest quantity of material for the history of the United States, and particularly for the period before 1783. For many subjects in the history of the colonial and revolutionary periods, indeed, there is much more unprinted manuscript in that one repository than in America itself.

Volume I, in its introduction, gives a history and description of the Public Record Office, its rules and regulations, and statements respecting such of its publications as are useful to American inquirers. The contents of the archive are classified in two grand divisions, the one that of State Papers, the other that of Departmental and Miscellaneous Records. Of these, it is the State Papers which are treated in the present volume. After an historical introduction upon the Secretary of State and his duties and upon the State Papers Office, the various series of State Papers Foreign, State Papers Domestic, Home Office Papers, State Papers Miscellaneous, State Papers Colonial, and Colonial Office Papers are described, with full presentation of details. These are most abundant in the section devoted to the Colonial Office Papers. The reclassification of the Colonial Office Papers has so completely made obsolete all previous descriptions that Professor Andrews's minute description of them in their present order or arrangement must be of the greatest utility to all students of American colonial history.

Volume II presents a detailed description, volume by volume, of the divisions of the Public Record Office known as Departmental Records and Miscellaneous. The Departmental Records comprise the papers of the Admiralty, the Audit Office (including the Declared Accounts), and the Lord Chamberlain's Department, the Commissariat, the Custom House, the Treasury, and the War Office. The Miscellaneous section embraces the records of the High Court of Admiralty, the Manchester, Cornwallis, Shaftesbury, Rodney, and Chatham papers, and those of the modern Board of Trade. The divisions of the Public Record Office embraced in this volume have been much less used for purposes of American history than the "State Papers" described in Volume I. The largest sections of the book are those relating to the Treasury, the Admiralty, the War Office, and the High Court of Admiralty. Each of the two volumes has its own index.

No. 90B. Paullin, C. O., and F. L. Paxson. *Guide to the Materials in London Archives for the History of the United States since 1783.* Octavo, xi+642 pages. Published 1914. Price $4.00.

This book is the result of several months of investigation in the Public Record Office, British Museum, and some other repositories in London, on the part of Dr. Paullin and Professor Paxson, supplemented by additional researches made by Prof. C. E. Fryer and Mr. David W. Parker. The volume furnishes a complement to those of Professor Andrews, and of Professor Andrews and Miss Davenport, by supplying similar guidance to materials for the later period. The official permissions for search originally extended to 1837 for most departments, but were later extended to 1860. Thus the book contains descriptive lists, for 1783 to 1860, of all the materials for the history of the United States which are to be found in the sections at the Public Record Office known as Foreign Office Papers, Home Office Papers, Colonial Office Papers, War Office Papers, Admiralty Papers, and many minor subdivisions. It likewise supplements the Andrews-Davenport volume by a mass of additional data respecting American materials in the British Museum.

No. 91. Shepherd, W. R. *Guide to the Materials for the History of the United States in Spanish Archives (Simancas, the Archivo Historico Nacional, and Seville).* Octavo, 107 pages. Published 1907. Price $0.50.

The three archives in Spain most abounding in materials for American history are those of Simancas, the Archivo Historico Nacional in Madrid, and the Archives of the Indies at Seville. Professor Shepherd, of Columbia University, after several months spent in the examination of these archives, provides in this volume a summary statement of all the leading classes in which the student of the history of the United States may find material for his purposes.

No. 124. Robertson, James Alexander. *List of Documents in Spanish Archives Relating to the History of the United States, which have been printed or of which Transcripts are Preserved in American Libraries.* Octavo, xv+368 pages. Published 1910. Price $2.25.

This book aims to assist those using No. 91 as well as other investigators of the history of the United States in its relation to Spain, by indicating all those documents useful to their purposes, in Spanish archives, which can be examined without going or sending to Spain. It consists of two lists. The first indicates, in chronological order and with proper references, all those documents of this sort which are already in print. The second is a list, in similar order, of all those which may be found in American libraries in the form of transcripts. A full index exhibits names of writers, names of persons addressed, and subjects.

No. 163. Bolton, Herbert E. *Guide to Materials for the History of the United States in the Principal Archives of Mexico.* Octavo, xv+553 pages. Published 1913. Price $3.50.

While presenting descriptive accounts of all the archives in Mexico examined by Professor Bolton, this volume is mainly occupied with lists of documentary materials bearing on the history of the United States. The largest part of it is devoted to such lists for archives in the city of Mexico; but a large number of provincial archives were searched, especially in the cities of northern Mexico upon which the regions now called Texas, New Mexico, Arizona, and California at one time depended, either in a civil or in an ecclesiastical sense. To a large extent these searches have been pioneer work, laying open treasures of material hitherto unexplored. Many of the documents bear upon the history of the relations between Mexico and the United States, especially about the time of the Mexican War; others illustrate in countless ways the progress of exploration, Spanish colonization, mission work, Indian hostilities, and American settlement in the present southwest. In the city of Mexico, to whose archives the major portion of the book is devoted, the repositories most largely reported upon are the national collections in the Archivo General y Publico and the archives of the executive departments, especially the Secretaria de Relaciones, the Secretaria de Gobernación, and the War Department.

No. 83. Peréz, Luis Marino. *Guide to the Materials for American History in Cuban Archives.* Octavo, x+142 pages. Published 1907. Price $0.75.

The Cuban archives, in spite of the removal of large quantities of papers to Spain in 1888 and 1898, and of many losses due to political changes, embrace a large mass of valuable historical material. The fact that, under the old administrative system of Spain, Florida and Louisiana were under the jurisdiction of the captain-general of Cuba, brings it about that considerable masses of these papers have a direct relation to the history of the United States. Mr. Peréz spent five months in the investigation of these papers. His book gives a general description of the Cuban archives, traces historically the development of the administrative system of Cuba, describes the principal archive material relating to the history of the United States, and furnishes an itemized list of the papers most important in this respect.

No. 128. Fish, C. R. *Guide to the Materials for American History in Roman and Other Italian Archives.* Octavo, ix+259 pages. Published 1911. Price $2.00.

Nine-tenths of this book relates to archives in Rome. In that city the two collections most abounding in materials for American history, and described in the

most detailed manner in this volume, are the archives of the Vatican and those of the Congregation of the Propaganda. The former embraces the correspondence of the papal secretaries of state with the nuncios of Spain, France, and other colonizing countries, and various correspondence with bishops and other ecclesiastics in America. Taken in connection with the archives of the Propaganda, or chief missionary office, these archives not only display with great fulness the ecclesiastical and religious history of early America and of the Catholic portions of the United States, but also cast an extraordinary amount of light upon the civil history and administration, especially French and Spanish. Besides the Vatican archives, the volume embraces the manuscripts in the Vatican Library, in other ecclesiastical collections, and in public and private libraries in Rome. The archives of Naples, Venice, Turin, and Florence are likewise included. There is a full index.

No. 150. Learned, M. D. *Guide to the Materials relating to American History in the German State Archives.* Octavo, vii+352 pages. Published 1912. Price $2.25.

German materials touch the history of the United States in the ordinary manner of diplomatic relations, and also, and in a very interesting manner, in the particular episode of the Hessian and other auxiliary troops in the American War of Independence. But the leading relation between German history and that of the United States has lain in the field of the history of German emigration, which, beginning in the seventeenth century and continuing to the present time, has contributed no doubt not less than one-fifth to the population of the United States. Therefore Professor Learned's inspection of German archives, though ample and detailed in the case of diplomatic archives and of the Hessian and other military papers, was far from being confined to these. On the contrary, he made an examination of all seventeen of the Prussian provincial state archives, of the eight provincial archives in Bavaria, and of the archives of the minor German states, making it his chief object to note volumes and papers which bore upon the history of the migration of German population to America. The volume is minutely indexed.

No. 220. Faust, A. B. *Guide to the Materials for American History in Swiss and Austrian Archives.* Octavo. In press.

In Switzerland there is some material for American history in the archives of the Confederation at Bern, but still more in the archives of the cantons. This is mainly because of the large emigration from the German-speaking cantons of Switzerland to America in the eighteenth and nineteenth centuries. Professor Faust has discovered, and listed or described, large masses of interesting papers exhibiting the history of this migration and the relations of the Swiss Government to it. The largest number were found in the cantonal archives of Zürich, Bern, and Basel. Descriptions of the state archives in the French-speaking cantons have been added, as a result of personal research, by the Director of the Department of Historical Research, Dr. J. F. Jameson. Professor Faust's researches in the Austrian archives cover those of Vienna, Salzburg, and Innsbruck. At Vienna, a valuable series of papers in the Hof-, Haus-, und Staats-archiv illustrates the history of the diplomatic relations between the United States and Austria. Papers in other governmental archives in Vienna, and in those of Salzburg and Innsbruck, illustrate the history of emigration from Austria to America.

No. 234. Hill, Roscoe R. *Descriptive Catalogue of the Documents relating to the History of the United States in the Papeles Procedentes de Cuba, in the Archivo General de Indias at Seville.* Octavo. In press.

Of all the various sections of the Archives of the Indies at Seville, the richest in material for the history of the United States is that called "Papeles procedentes de la Isla de Cuba." This is a mass of correspondence, documents, and records, which was transferred to Spain in 1888 from Havana, where it had constituted a part of the archives of the office of the Captain-General, "dead files" relating to regions outside of Cuba and no longer in his jurisdiction. Out of about 2,500 *legajos* (bundles) which were thus transferred, some 934 relate to regions now forming a part of the continental territory of the United States.

The total number of documents in these lies between 400,000 and 500,000, and the whole constitutes a very important mass of material for the history of the United States, chiefly of Florida, West Florida, Louisiana, and the Mississippi Valley, in the period from 1763 to 1819. Mr. Hill's book, the product of more than two years' labor in Seville on his part and that of clerical assistants, describes the contents of each of these *legajos* as fully as this can be done in the average space of half a page or a little more, and with such fullness of detail as to personal and geographical names as will enable investigators to find whatever material in this section of the archives relates to the particular subject of their inquiries. An itemized list of all the documents in 158 of the most important *legajos* is kept in manuscript in the office of the Department of Historical Research, which has also photographed a series of more than 2,000 of the chief documents.

HANDBOOK OF LEARNED SOCIETIES.

No. 39. *Handbook of Learned Societies and Institutions—America.* Octavo, VIII+592 pages. Published 1908. Price $4.00.

The above gives a practically complete list of the important learned societies and institutions of North and South America, with their locations and addresses, followed in most cases by a brief statement of the history and object of the society concerned, and including data with regard to meetings, membership, publications, research funds, and prizes.

AMERICAN ECONOMIC HISTORY.

No. 215A. JOHNSON, EMORY R., T. W. VAN METRE, G. G. HUEBNER, and D. S. HANCHETT, with an introductory note by H. W. FARNAM. *History of Domestic and Foreign Commerce of the United States.* Octavo (2 vols.) Published 1915. Price $6.00.
Vol. I. xv+363 pages.
Vol. II. ix+398 pages.

This History of Domestic and Foreign Commerce of the United States, in two volumes, constitutes one division of the Contributions to American Economic History being prepared by the Department of Economics and Sociology of the Carnegie Institution of Washington. Volume I contains three parts dealing, respectively, with "American Commerce to 1789," "The Internal Commerce of the United States," and "The Foreign Trade of the United States Since 1789." Volume II also has three parts devoted, respectively, to "American Fisheries," "The Coastwise Trade of the United States," and "Government Aid and Commercial Policy;" this volume also contains a bibliography topically classified.

Part one of Volume I, with the exception of two chapters, was written by Emory R. Johnson, Professor of Transportation and Commerce at the University of Pennsylvania, while the remainder of the two volumes was written by Dr. T. W. Van Metre, Assistant Professor G. G. Huebner, and Dr. David S. Hanchett. Several collaborators made special studies that were used along with other material in writing the volumes. Professor Johnson has directed the preparation of the entire work and has edited the parts contributed by his associates.

No adequate history either of the foreign or of the internal trade of the United States had previously been written. While there is a large literature upon commercial subjects to be found in government reports and other publications, these volumes are the first to cover systematically the entire field of the history of American commerce.

No. 215B. CLARK, VICTOR S. *History of Manufactures in the United States, 1607 to 1860.* Octavo. In press.

This volume contains a history of American manufactures from the settlement of Virginia to the Civil War. Its purpose is to picture and to explain the beginnings of that growth which has made manufacturing one of the most important forms of natural production. The more important economic influences affecting general manufactures and specific industries are described and their relation to our industrial development is traced in detail. While the arrangement is loosely chronological, the topical method of treatment prevails. There are very full references to the published and unpublished materials, and the book contains new statistical and bibliographical data of importance.

INDEXES TO STATE DOCUMENTS.

No. 85. Hasse, Adelaide R. *Index of Economic Material in Documents of the States of the United States.* Prepared for and under the direction of the Department of Economics and Sociology of the Carnegie Institution of Washington. Separate volume for each State. Quarto.

85 (Maine) (1820-1904), 95 pages..... $0.75
85 (New Hampshire) (1789-1904), 66 pages..... 0.50
85 (Vermont) (1789-1904), 71 pages..... 0.50
85 (Massachusetts) (1789-1904), 310 pages..... 2.25
Banks 14 pp., education 15 pp., insurance 15 pp., charities and corrections 15 pp., railroads (Troy and Greenfield R. R. and Tunnel 213 entries) 33 pp., vital statistics 16 pp.
85 (Rhode Island) (1789-1904), 95 pages..... 0.75
85 (New York) (1789-1904), 553 pages..... 3.75
Banks 34 pp., canals 34 pp., insurance 19 pp., charities and corrections 53 pp., railroads 19 pp., taxation 36 pp.
85 (California) (1849-1904), 316 pages..... 2.25
Agriculture 36 pp., climate 13 pp., education 17 pp., charities and corrections 24 pp., natural resources 26 pp.
85 (Illinois) (1809-1904), 393 pages..... 5.00
Agriculture 71 pp., banks 11 pp., canals 21 pp., education 23 pp., charities and corrections 30 pp., railroads 31 pp., taxation 13 pp.
85 (Kentucky) (1792-1904), 452 pages..... 5.00
85 (Delaware) (1789-1904), 137 pages..... 1.50
85 (Ohio) (1787-1904), 1136 pages..... 14.00
85 (New Jersey) (1789-1904), 705 pages..... 8.00
85 (Pennsylvania) .....In press

In preparing the above volumes the term economic has been liberally interpreted. The index embraces reports of the boards of agriculture, charities and corrections, education, public works and public health, banking, insurance, railroad and tax commissions, bureaus of labor and vital statistics, climate and crop bulletins, geological surveys, fish, game, and forest commissions, auditors' and treasurers' reports, immigration, sewerage and water-supply, roads, canals and river conservancy, governors' messages, and reports of attorneys general. Particular care has been taken in reading the above-mentioned reports to note recommendations, suggestive comment, and especially the character of the tabulations. A checklist of the entire file of reports accompanies each subject. The indexed material is arranged chronologically under each subject. Thus the student is able to trace the historical development of each economic subject as it is reflected in the documents of an individual State. The work is published by States, a single volume to a State, and is designed to cover the period from the adoption of the Federal Constitution to the close of the year 1904.

INDEX TO UNITED STATES DOCUMENTS RELATING TO FOREIGN AFFAIRS.

No. 185. Hasse, Adelaide R. *Index to United States Documents Relating to Foreign Affairs, 1828-1861.* In 3 parts. Quarto. In press.
Part I, A to H, pages 1 to 793, issued.

The Folio American State Papers (Foreign Affairs), which ceased in 1828, have indexes, and an index to the annual Diplomatic Correspondence beginning in 1861 has been published by the State Department. The present publication indexes the documents of the intervening period, from 1828-1861. It affords reference to the entire published record of documents, papers, correspondence and, to a considerable extent, legislation and decisions upon international or diplomatic questions. In addition to the reports of Congress, the following series of documents have been indexed: the Senate Executive Journal, for diplomatic and consular appointments and treaty ratifications; the Opinions of the Attorneys General, for decisions on questions of international controversy; the Statutes-at-Large, for acts and resolutions relating to international affairs; and the Congressional Globe and its predecessors for speeches and correspondence. The text of the latter, it was found, does not always correspond with the text as printed in the House and Senate documents.

LITERATURE.

No. 74. Sommer, H. Oskar. *The Vulgate Version of the Arthurian Romances. Edited from MSS. in the British Museum.* Quarto. In seven volumes. Price per volume, $5.00.

This publication will be of especial importance to the student of mediæval literature, particularly to all interested in the study of the mass of fiction centering around the immortal King Arthur of Great Britain. It represents the first attempt to produce a complete printed text of the whole of the Vulgate Cycle comprising the early history of the Holy Grail; the prose-rendering of Robert de Borron's Merlin and the Book of Arthur; the huge compilation of adventures known as the Book of Syr Lancelot of the Lake; the Quest of the Holy Grail; and the Death of Arthur.

The text is a faithful reproduction of one of the six manuscripts known containing the entire Vulgate Cycle, viz, the Add. MS. 10292-10294 of the British Museum. It has been collated, supplemented, and corrected by help of other manuscripts representing only certain sections of the cycle in the same library and in some special cases by the help of manuscripts in the Bibliothèque Nationale, of Paris. The lines are numbered and reference numbers to other manuscripts and printed editions are added throughout. Ample side-notes in English are supplied.

In his Introduction Dr. Sommer briefly outlines the results of his studies on the genesis of the Vulgate Cycle. His views differ in many essential points from those hitherto accepted as probable or correct.

Volume I: Lestoire del Saint Graal, 296 pages.
Volume II: Lestoire de Merlin, 466 pages.
Volume III: Le Livre de Lancelot del Lac. Part I, 430 pages.
Volume IV: Le Livre de Lancelot del Lac. Part II, 399 pages.
Volume V: Le Livre de Lancelot del Lac. Part III, 474 pages.
Volume VI: Les Aventures ou La Queste del Saint Graal. La Mort le Roy Artus. 388 pages.
Volume VII: Le Livre d'Artus. MS. No. 337, Bibliothèque Nationale. 370 pages.
Index of Names and Places to above volumes. In press.

No. 89. Hodell, Charles W. *The Old Yellow Book: Source of Browning's "The Ring and the Book."* Octavo, cclxii+345 pages, 4 plates. Published 1908. Price $7.00. (Out of print.)

A complete photo-reproduction of "The Old Yellow Book," the source of Browning's "The Ring and the Book," with translation, essay, and notes by Prof. Charles W. Hodell, of the Woman's College of Baltimore, Maryland. The volume is a large octavo, the reproduction occupying 262 pages, and the preface, translation, essay, notes, and index 345 pages additional. The work is printed on paper of very high quality, and contains portraits of Browning and of Guido Franceschini, the coat of arms of the Franceschini family, and a facsimile of the death record of Pompilia.

A second edition of the above is in press.

No. 171. Lancaster, H. C. *Pierre Du Ryer, Dramatist.* Octavo, v+182 pages, 1 plate. Published 1912. Price $1.25.

Pierre Du Ryer wrote at the time when the drama of modern France was first gaining national significance. The group of authors to which he belonged established the French classic drama as a distinct literary form, composed many tragi-comedies, both classic and romantic, originated for their country the comedy of manners, and did much to develop the technique of dramatic composition and representation. A thorough understanding of their achievement requires a careful study, not only of Corneille, the most important of these dramatists, but also of the lesser writers, who often showed the way to their illustrious contemporary. The present volume studies exhaustively the life and plays of Du Ryer, who, after Corneille, was in many ways the leading member of the group. Du Ryer's translations and lyric poems are treated in their relation to his life and dramatic work. The book contains an index, and is illustrated by vignettes and a plate reproduced from an early edition of Du Ryer's tragedy "Saul."

No. 189. Osgood, Charles G. *A Concordance to the Poems of Spenser.* Quarto, xiii+997 pages, 1 plate. Published 1915. Price $20.00.

This book is an alphabetical list of all the words in the English poems of Edmund Spenser. Under each word are quoted all the passages in which the word occurs, except that for a few very frequent and unimportant words only a selected list of quotations is given. The context of the word in each quotation is selected so as to show, as far as space allows, the meaning and use of the word. The whole work contains nearly 200,000 quotations. It is based upon the text of Richard Morris, revised and corrected by editions which have appeared since the concordance was begun. Spenser is usually ranked fourth among English poets, and his place in the history both of the English language and of English poetry is peculiarly important. The object of the concordance is not only to illuminate the poet's meaning and art in the use of words, but to afford aid to the historical study of the language and literature similar to that to be derived from concordances to the Bible, Shakespeare, Milton, Pope, Wordsworth, and other English poets.

No. 202. Cooper, Lane. *An Exhaustive Concordance of Horace.* Octavo. In press.

This strictly analytical work records, in alphabetical order, every occurrence of every word in Horace, and all the variant readings included in two standard modern editions of the poet. Under each word is quoted every passage in which the word occurs, with a numerical reference to poem and line; save that in the case of a few particles, no quotations, but numerical references alone are given. The basic text is that of Friedrich Vollmer (Leipsic, Teubner, 1912); his list of variants has been supplemented by the inclusion of a few readings noted in the edition of Wickham (Oxford, Clarendon Press, 1903-1904). The arranging of related grammatical forms under one heading has not been attempted; but homographs—for example, datives and ablatives ending in *o*—have been carefully separated. No effort has been spared to make the book typographically clear and easy to consult.

The thought and language of Horace have exerted a profound and widespread influence upon subsequent poets, English as well as Continental. In common with other Latin authors, his works have in times past been indexed; but of the previous verbal indexes still in print there is none that duly performs the functions of a concordance or adequately serves the purposes of the students of modern as well as ancient literature. Zangemeister's edition (now out of print) of Bentley's Horace contains an index which is virtually a concordance, but the typographical arrangement is so bad and the progress of studies in the text of Horace since 1869 has been so great, that, were his index more accessible, there would still be room for a new work. The present concordance was undertaken in view of difficulties actually experienced, with various indexes, in the comparison of English poets with Horace.

No. 208. Broughton, L. N., M. R. Thayer, and others. *A Concordance to the Poems of Keats.* Quarto. In press.

This work contains an alphabetical list of the words in the poems of John Keats. Under each word, except for a very small list of unimportant words, is quoted every metrical line in which the word occurs, approximately 65,000 quotations in all. The basic text is that of H. Buxton Forman, C. B. (Oxford University Press). The recording was done from the issue of 1910; but has been carefully collated with the issue of 1914, which contains five newly discovered poems. The page numbers given in the concordance correspond to those of the later issue, but for the convenience of those using the earlier text a table in the introduction carefully and completely records the relatively small number of changes in pagination. The text is supplemented by the variant of *La Belle Dame sans Merci* from Lord Houghton's *Life and Letters of Keats.*

PHILOLOGY, ETC.

No. 169. Callaway, Morgan, Jr. *The Infinitive in Anglo-Saxon.* Octavo, xiii+339 pages. Published 1913. Price $5.00.

In this work Professor Callaway gives a detailed history of the Infinitive in Anglo-Saxon and treats of some substitutes therefor. The study is based upon a statistical reading of the whole of Anglo-Saxon literature with the exception of the glosses and of a few out-of-prints; moreover, in all of the more definitely known translations, the Latin originals have been read. The statistics are given clearly and are complete except for the predicative infinitive with auxiliary verbs, the full tabulation of which seemed unnecessary. Fifteen chapters of interpretation are based upon this material. A long chapter is added on "The Infinitive in the Other Germanic Languages," which of necessity rests upon the investigations of others, but which will, it is believed, be found something more than a summary. The bibliography makes no pretensions to exhaustiveness, but is fuller than any hitherto published in this field. It is thought that the monograph will appeal to students of Germanic syntax scarcely less than to students of English syntax, for the work is written throughout from the comparative standpoint.

No. 134. Churchill, William. *The Polynesian Wanderings. Tracks of the Migration deduced from an Examination of the Proto-Samoan Content of Efaté and other Languages of Melanesia.* Octavo, viii+516 pages, 2 plates. Published 1911. Price $3.50.

Two theories of the origin of the brown Polynesian race of the Pacific are here discussed, the Semitic and the Malayan theories respectively. It has been essayed to dispose of these definitely by the methods of comparative philology. To that end the author has amassed all available data from all the Polynesian languages and from 150 used in Melanesia and 50 Indonesian tongues; he has discussed their phonetic mutations and therefrom has pronounced against each of these theories. Dealing with the Polynesians as a pre-Malayan population of Indonesia, he shows that the race advanced upon the Pacific in two swarms separated by a wide interval of time. Confining his investigation to the earlier swarm, at or about the beginning of the present era, he outlines two streams of migration parted at the outset by the obstacle of New Guinea and not brought into association until their arrival in Nuclear Polynesia. As a contribution to the philology of the isolated tongues it is indicated that these studies set us at a point of examination but narrowly removed from the genesis of one of the languages of human speech.

No. 154. Churchill, William. *Beach-la-mar: The Jargon or Trade Speech of the Western Pacific.* Octavo, 54 pages. Published 1911. Price $0.50.

This work is directed toward two ends. The preservation of the vocabulary is expected to afford material for those students who may be attracted to the prosecution of research upon jargons as underlying the artificial languages in general, a theme as yet untouched in philological examination. The discussion of the grammar of this crude means of communication has a value of its own as a preliminary step in the consideration of the grammar of isolating speech, a study essential to the establishment of the newer philology based upon the most primordial stage of the evolution of human speech.

No. 174. Churchill, William. *Easter Island, Rapanui Speech, and the Peopling of Southeast Polynesia.* Octavo, 340 pages. Published 1912. Price $2.75.

Herein have been assembled the word-lists of all former students of Easter Island, the French vocabulary compiled by Père Hippolyte Roussel, the words recorded by Geiseler, Thomson, and Cook, together with the author's own collections. To this material has been added the necessary philological apparatus wherewith to make this the first dictionary of the speech of this remote outlier of the Polynesian race. Prefaced to the dictionary is a discussion of the various languages of southeastern Polynesia, namely, those of Tahiti, the Marquesas, the Paumotu, and

Mangareva. This material has been employed to dissociate the several streams of Polynesian migration which have moved eastward from Samoa under the heliotropic impulse which has ever been active in this great movement of folk migration. In these studies it has been possible to dissect out earlier and later migrations and to a satisfactory extent to translate into terms of geography the results of philological comparison.

No. 184. Finley, J. P., and William Churchill. *The Subanu: Studies of a Sub-Visayan Mountain Folk of Mindanao.* Octavo, iv+236 pages, 2 plates. Published 1913. Price $2.00.

In Part I of this work Colonel John Park Finley, U. S. Army, has furnished a record of the present stage of this mountain tribe of Mindanao, a race hitherto practically untouched by even such culture as the Moros of the coast possess. Since St. Francis Xavier gave them up in despair they have remained in unmixed savagery until now they are being brought within the civilizing efforts of American endeavor. This record is as complete as could be obtained by ten years of administrative contact with this shy and rude folk. In collating the linguistic material collected in the intervals of campaigns by the military author, Mr. Churchill has established the ethnic position of the race as archetypal in reference to the more widely extended Visayan culture. This theme leads naturally to a careful discussion of the Malayo-Polynesian speech family and the employment of this important collection of new data to accomplish its demolition, thus clearing the way for a free study of the respective language units which hitherto have been obscured by an untenable association.

No. 244. Churchill, William. *Sissano: Movements of Migration within and through Melanesia.* Octavo. In press.

Newly available material derived from the Sissano, a people on the Aróp lagoons on the north coast of New Guinea, has been utilized in this work for the study of one of the more intricate problems of the track of Polynesia migration out of Indonesia. Objection has been raised against the suggestion that two migration tracks were discernible in reference to New Guinea as in part obstacle and in part conduit of folk movement. These tracks have been traced along the north coast of the island and along the south coast through Torres Strait. It has been suggested that the traces of Polynesian speech found in the Gulf of Papua have reached that area by coastwise voyaging from the north coast to the southeast peninsula and thence westward. By the employment of the speech material from Sissano for the explication of the similar material found in the Torres Strait tract it is established that all the evidence at present available indicates the probability of the folk movement eastward from the Arafura Sea through Torres Strait independently of the movement along the north coast.

FOLK-LORE.

No. 17. Dorsey, George A. *Traditions of the Arikara.* Octavo, 202 pages. Published 1904. Price $1.00.

A collection of eighty-two folk tales of the Arikara Indians of North Dakota, a tribe of the Caddoan stock, most nearly related to the Skidi Pawnee. The tales are arranged in groups as follows: Creation Myths; Transformation Myths; Rite Myths; Miscellaneous; Animal Tales; Traditions embodying superstitions or strange beliefs and wild tales. There is an introduction, and abstracts of each tale are given.

No. 21. Dorsey, George A. *Mythology of the Wichita.* Octavo, viii+351 pages. Published 1904. Price $1.50.

A collection of sixty tales of the Wichita tribe of the Caddoan stock, living in Oklahoma. The tales are arranged according to certain Wichita cosmogonic conceptions, namely, Creation, Transformation, and Present. Several of the tales are represented by one or more variants. An introduction gives a general account of Wichita ethnology. The tales are all provided with abstracts.

No. 41. Dorsey, George A. *Traditions of the Caddo.* Octavo, 136 pages. Published 1905. Price $0.50.

The Caddo tales presented in the above publication were collected during the years 1903-1905 and form part of a systematic investigation of the religious system and ceremonial organization of the tribes of the Caddoan stock. The Caddo since 1859 have lived in western Oklahoma, between the Washita and Canadian rivers, where they have been closely associated with the Wichita. They retain practically nothing of their ancient culture. Their early home was in Louisiana, on the lower Red River. Later they migrated toward the Texas border, and still later to Brazos River in Texas. Like the Wichita, their early habitations were conical grass lodges, and they were agriculturists, hunting the buffalo only within comparatively recent times.

No. 59. Dorsey, George A. *The Pawnee: Mythology* (Part I). Octavo, 546 pages. Published 1906. Price $2.00.

A collection of 148 tales of the Pawnee, representing the Chaui, Kitkehahki, Skidi, and Pitahauirat, which constitute the four bands of the Pawnee who to-day live in Oklahoma. This volume forms a supplement to Traditions of the Skidi Pawnee, Volume III of the Memoirs of the American Folk-Lore Society. The tales are grouped according to the Pawnee conception of tales: True Stories of the Heavenly Beings; Tales of Ready-to-Give; The Origin of Medicine Ceremonies or Power; Coyote Tales. A brief introduction relates the method of obtaining the material and all the tales are furnished with abstracts. Many of the tales contain one or more songs.

EMBRYOLOGY.

No. 191. Weed, Lewis H. *A Reconstruction of the Nuclear Masses in the Lower Portions of the Human Brain-Stem.* (Contribution to Embryology.) Quarto, 78 pages, VI plates. Published 1914. Price $2.50.

This comprises a study of the form and relations of the collections of ganglion cells making up the nuclei of the upper cervical cord and medulla of the adult human brain. It is a description of a model made by reconstructing, in wax, a series of 900 cross-sections, 40μ thick, taken through a normal human brain stem, treated by the Weigert-Pal method. This model is illustrated from the dorsal, lateral, and ventral aspects, and embraces a special morphological study of the nucleus olivaris inferior. The conformation of each nuclear mass is described in its relation to the surface and to the surrounding structures.

No. 221. Mall, Franklin P. *On the Fate of the Human Embryo in Tubal Pregnancy.* (Contribution to Embryology, No. 1.) Quarto, 104 pages, 11 plates, 24 text figures. Published 1915. Price $5.00.

No. 222. Contributions to Embryology, Nos. 2, 3, 4, 5, and 6. Quarto, 108 pages. Published 1915. Price $3.00.

This book contains the following papers, *not sold separately:*

Watt, James C.—Description of Two Young Twin Human Embryos with 17-19 paired Somites. (Contribution No. 2.) 39 pages, 4 plates, 7 figs.

Clark, Eliot R.—An Anomaly of the Thoracic Duct with a bearing on the Embryology of the Lymphatic System. (Contribution No. 3.) 10 pages, 3 figs.

Meyer, A. W.—Fields, Graphs, and other Data on Fetal Growth. (Contribution No. 4.) 14 pages, 13 figs.

Corner, George W.—The Corpus Luteum of Pregnancy as it is in Swine. (Contribution No. 5.) 24 pages, 3 plates.

Essick, Charles R.—Transitory Cavities in the Corpus Striatum of the Human Embryo. (Contribution No. 6.) 14 pages, 2 plates.

No. 223. Contributions to Embryology, Nos. 7, 8, and 9. Quarto, 90 pages. Published 1915. Price $5.00.

This book contains the following papers, *not sold separately:*

Sabin, Florence R.—On the Fate of the Posterior Cardinal Veins and their relation to the Development of the Vena Cava and Azygos in the Embryo Pig. (Contribution No. 7.) 32 pages, 7 plates.

Duesberg, J.—Recherches Cytologiques sur la Fécondation des Ascidiens et sur leur Développement. (Contribution No. 8.) 38 pages, 3 plates.

Shipley, Paul G., and George B. Wislocki.—The Histology of the Poison Glands of *Bufo agua* and its bearing upon the formation of Epinephrin within the Glands. (Contribution No. 9.) 20 pages, 2 plates.

No. 224. Contributions to Embryology, Nos. 10, 11, 12, and 13. Quarto. In press.

This book contains the following papers, *not sold separately:*

Mall, F. P.—The Human Magma Reticulé in Normal and in Pathological Development. (Contribution No. 10.) 3 plates.

Cowdry, E. V.—The Structure of Chromophile Cells of the Nervous System. (Contribution No. 11.) 1 plate.

Cunningham, R. S.—On the Development of the Lymphatics of the Lungs in the Embryo Pig. (Contribution No. 12.) 5 plates.

Macklin, Charles C.—Binucleate Cells in Tissue Cultures. (Contribution No. 13.)

No. 225. Weed, Lewis H. *Development of the Cerebro-spinal Spaces.* (Contribution to Embryology, No. 14.) 17 plates. In press.

INDEX MEDICUS.

A Monthly Classified Record of the Current Medical Literature of the World.

The Index Medicus was established in 1879, under the editorship of Dr. John S. Billings and Dr. Robert Fletcher, and was discontinued in 1899. The volumes of this first series are now out of print. The Carnegie Institution of Washington began the printing of the second series with the number of January 1903. Each number presents the literature of the month named on its cover and is issued as early as possible in the succeeding month, time being allowed for the arrival of foreign journals. The editor is Fielding H. Garrison, M.D.

This publication consists of the titles in full of books, pamphlets, theses, contributions to co-operative works and original articles in journals, transactions of medical and scientific societies, and the like, arranged under subject-headings. The titles in certain languages, as Russian, Polish, Swedish, Danish, Finnish, Hungarian, Bohemian, Roumanian, and Japanese, are translated into English. A table of contents accompanies each number, and a few months after the completion of each volume an "Annual Index of Authors and Subjects" is issued. The subject part of this annual index is elaborately subdivided, the classification resembling that of the Index Catalogue of the Library of the Surgeon General's Office, U. S. Army.

Of the second series Vols. I-VI (1903-1908) are available at the original rate of $5.00 a volume, with 60 cents additional for postage when sent to foreign countries; Vols. VII to XIV at the present rate, as follows:

United States, Canada, and Mexico.....$8.00
Other countries 8.60

Remittances should be made by money order or New York exchange. All communications should be addressed

Carnegie Institution of Washington, Washington, D. C.

NUTRITION AND OTHER SUBJECTS OF ALLIED INTEREST.

No. 42. Atwater, W. O., and F. G. Benedict. *A Respiration Calorimeter with Appliances for the Direct Determination of Oxygen.* Octavo, 193 pages, 49 figures. Published 1905. Price $1.25.

A technical description of an apparatus for use in experiments with man, permitting the simultaneous determination of carbon dioxide, water-vapor, heat elimination, and oxygen absorption. The respiration apparatus is of the closed-circuit type of Regnault and Reiset, the unique feature of which is the accurate determination of oxygen. The calorimeter is of the continuous-flow type, provided with arrangements for keeping the walls adiabatic. The apparatus was developed and constructed in the Chemical Laboratory of Wesleyan University, where it was in use for a number of years, and many experiments on man were made with it. One such experiment is described in this report.

No. 77. Benedict, F. G. *The Influence of Inanition on Metabolism.* Octavo, vii+542 pages, 2 text figures. Published 1907. Price $2.75.

An extended investigation by means of the respiration calorimeter on the influence of varying degrees of inanition upon metabolism. Fourteen experiments were made with 10 different individuals and the fasting period extended from 2 to 7 days, during which time the subject was inside the respiration chamber. The complete metabolism was studied and the discussion includes an extended consideration of the influence of inanition on body-weights, temperature, pulse, respiration, blood, strength, feces, urine, water excretion, carbon-dioxide elimination, oxygen consumption, and the transformation of energy. Two nitrogen metabolism experiments throw considerable light upon recuperation after fasting.

No. 123. Benedict, Francis G., and T. M. Carpenter. *Respiration Calorimeters for Studying the Respiratory Exchange and Energy Transformations of Man.* Octavo, vii+102 pages, 32 figs. Published 1910. Price $0.75.

In the two calorimeters, one of them for bed-ridden patients, the heat eliminated by man is measured by a current of cold water passing through a heat-absorbing system inside the chamber, the mass of water and the temperature-rise being known. Direct measurement of the water vaporized gives the latent heat of water-vapor. By means of a system of thermal junctions, any slight temperature differences between the inner copper wall and an outer zinc wall are constantly noted. The temperature of the zinc wall is arbitrarily adjusted by heating and cooling to maintain it at the temperature of the copper wall, thus holding the calorimeter in an adiabatic condition. The chambers are large enough for a man to remain comfortably seated or lying for several hours, an electric light furnishes illumination, connection is made by call-bell and telephone with the outside, and a supply of air is continually circulated through the chamber, and thence through weighed vessels containing sulphuric acid and soda lime to absorb quantitatively water-vapor and carbon dioxide. The oxygen consumed is determined by admitting the gas from a weighed cylinder of highly compressed pure oxygen. Analyses of the air residual in the chamber are made at the end of every period, and corrections for barometric changes are applied. Electrical resistance thermometers are used to measure calorimeter as well as body temperatures. A stethoscope and pneumograph permit the measurement of the pulse-rate and respiration-rate. A graphic record of the minor muscular movements is also furnished by the tracing of the pneumograph tambour. The apparatus has been most carefully checked as a calorimeter by the development of the heat from a known electrical current inside the chamber, and the accuracy of measurement of all four factors—carbon dioxide, water-vapor, oxygen absorption, and heat production—has been controlled by burning known weights of pure ethyl alcohol. The methods of calculation and the details of the routine of an experiment with man are included.

No. 126. Benedict, Francis G., and T. M. Carpenter. *The Metabolism and Energy Transformations of Healthy Man during Rest.* Octavo, viii+255 pages. Published 1910. Price $1.75.

In the decade during which the experiments were in progress with the respiration calorimeter at Wesleyan University, Middletown, Connecticut, a large amount of material on the normal metabolism of healthy men and women was accumulated. This material has been in part published in other reports, but much of it has never been published and is collected here for final presentation. Among the subjects discussed in detail are the changes in body-weight, the insensible perspiration, body-temperature with its variations and fluctuations, and pulse-rate. By means of the respiration apparatus, important data with regard to the vaporization of water from the body of the subject were accumulated, and these are discussed at some length in connection with the elimination of carbon dioxide, oxygen consumption, and the heat elimination and heat production. Special reference is made to comparison between the metabolism during sleep and during waking hours and the relationship between the different factors of metabolism. The variations in metabolism due to variations in physical characteristics, age, muscular activity, sex, etc., have received especial attention, including the metabolism of athletes, non-athletes, and women. Experiments dealing with the metabolism and energy transformations incidental to simple every-day movements are included, and tentative tables for computing the metabolism of normal individuals with varying degrees of muscular activity are given.

No. 136. Benedict, Francis G., and Elliott P. Joslin. *Metabolism in Diabetes Mellitus.* Octavo, vi+234 pages, 2 plates. Published 1910. Price $2.00.

This publication records in detail the study of the metabolism of 13 diabetic patients by means of the respiration calorimeters of the Nutrition Laboratory. The investigation included 42 experiments lasting 2 to 6 hours, 14 hours after the last meal, together with 11 experiments following ingestion of food. In these experiments the water elimination, carbon-dioxide production, oxygen consumption, and heat elimination and production were determined, and simultaneous determinations were likewise made of the body-temperature, pulse-rate, and respiration-rate. Besides experiments with the respiration calorimeters, 26 experiments were made with a respiration apparatus which permitted very exact determination of carbon-dioxide production and oxygen absorption. The urine was collected and the nitrogen and sugar determined in all these experiments.

Complete details of the investigation are reported in this publication, together with the clinical history of each case. A summary is given of the gaseous exchange and energy transformation in these experiments, and the averages are compared with those for normal individuals in experiments with the same apparatus. The metabolism in diabetes of different degrees of severity is compared.

Some of the other topics discussed are the nitrogen excretion, the dextrose-nitrogen ratio and its significance, the respiratory quotient, which is compared with the dextrose-nitrogen ratio, the vaporization of water from the lungs and skin, and the influence of food on the nitrogen and sugar excretions, on the respiratory exchange, and on the total katabolism. The report concludes with a discussion of practical features in the treatment of diabetes on which light has been thrown by this investigation, including a consideration of the quantities of food allowed diabetic patients, the restriction of the diet, and the advisability of making the diabetic sugar-free. The value of the respiration calorimeter in studying diabetes mellitus is shown, and suggestions are made for further investigations on this subject.

No. 176. Benedict, Francis G., and Elliott P. Joslin. *A Study of Metabolism in Severe Diabetes.* Octavo, vi+135 pages. Published 1912. Price $1.25.

Since the publication of the earlier results of the investigation on diabetes mellitus (Publication No. 136 of the Carnegie Institution of Washington), a considerable amount of research has been carried out with especial reference to the metabolism in severe cases of diabetes. The results of the later investigation are reported in Publication No. 176, and include experimental data regarding 17 cases, 6 of which were also studied in the earlier part of the research. Of these 17 cases, all

but 3 are classified as "severe diabetes." The apparatus and methods used were substantially the same as those previously employed, but the sugar in the urine of the diabetics was determined by an improved method, a description of which is given.

The attempt was made to study the individual cases more systematically and completely, at least 3 of the cases being carefully observed over a considerable period of time. The clinical history of each case is given, with complete details of the experiments. The pulse-rate, body-temperature, body-weight, nitrogen excretion, and gaseous metabolism are discussed in some detail, considerable attention being given to body-weight. Since loss of weight is a marked feature of diabetes, and these changes should be interpreted intelligently, the fluctuations in body-weight of normal individuals are considered at some length; a comparison is also made of the body-weights of the diabetics before onset with those in disease, and data given regarding the loss in weight of some 200 diabetics. To obtain evidence as to whether or not the metabolism is increased in diabetes, the results secured with the individual subjects are compared with the data found in experiments with one or more normal individuals who were comparable in body-weight and height. Comparisons are also made of the metabolism of diabetics with varying degrees of severity and under varying conditions as to the intensity of the acidosis, thus giving opportunity to study the relationship between the severity of the diabetes and the degree of increased metabolism. Further evidence is supplied by a study of the influence of an experimentally induced acidosis upon the metabolism of a normal individual, experiments being made with two subjects in which a carbohydrate-free diet was given.

As a result of these investigations, the conclusion is drawn that the metabolism in diabetes is increased above the normal about 15 per cent, thus confirming the conclusion given in the first report. The authors also believe that there is a close relation between the intensity of the metabolism and the severity of the disease, this being indicated not only in the comparison of the metabolism in light cases of diabetes with that in severe cases, but also in the comparison of the metabolism of the same individual with varying degrees of acidosis, and by the fact that normal individuals on a carbohydrate-free diet showed an increase in metabolism.

No. 155. Benedict, Francis G., and Edgar P. Slack. *A Comparative Study of Temperature Fluctuations in Different Parts of the Human Body.* Octavo, v+73 pages, 38 figures. Published 1911. Price $0.50.

In the research reported in this publication, a study was made of the simultaneous fluctuations in body-temperature with reference to determining (1) the best place for an accurate and constant measurement of body-temperature; (2) the temperature gradient of the body; and especially (3) whether or not the temperature fluctuations occurring in the different parts of the body are uniform. The thermal-junction method was employed and a special apparatus was constructed, which consisted of electrical measuring instruments, a thermal-junction system, and a constant-temperature oven. The apparatus and method are described in detail.

In studying the thermal gradient of the body the rectum was used with men, and the rectum and the vagina with a woman. The measurements were usually made with a double thermometer inserted at varying depths, the results being presented in the form of curves. In selecting the localities for the measurement of the body-temperatures, a special study was made of temperature measurements in the mouth with both clinical thermometers and thermal-junction thermometers.

In the study of the simultaneous fluctuations of body-temperature, 24 experiments were made, the subjects including five men and one woman. Measurements were obtained of the temperature in the rectum, vagina, and mouth, also in various artificial cavities, such as in the closed axilla and groin, between the clasped hands, and at various surface points which could be sufficiently closed by flesh to form a temporary cavity. These results are also expressed in the form of curves.

The discussion considers such questions as the temperature gradient, the effect of various superimposed factors on body-temperature, and the course of the temperature curves in different parts of the body drawn from simultaneous observations.

The general conclusion is drawn from the research that, aside from the skin temperature, a rise or fall in temperature of the rectum or vagina is accompanied by an equal rise or fall in temperature of all other parts of the body.

No. 166. Benedict, Francis G. *The Composition of the Atmosphere, with Special Reference to its Oxygen Content.* Octavo, iii+115 pages, 1 plate. Published 1912. Price $2.00.

The object of this investigation was to obtain an exact knowledge of the composition of outdoor air, for in studying the character of combustion processes in the body such knowledge is essential for the interpretation of the changes in the composition of air as it passes through the lungs. The first part of the publication consists of an extensive review of the earlier literature on the subject and a history of air analysis. The second part gives a description of a gas-analysis apparatus devised by Dr. Klas Sondén, of Stockholm, together with the technique of its use and the results of a series of analyses of outdoor air made at the Nutrition Laboratory during a period of nearly three years. The steps in the elimination of individual errors in the technique and routine are carefully traced, and the conclusion is reached that uncontaminated outdoor air in Boston is of constant oxygen content, irrespective of conditions of weather, humidity, temperature, barometer, wind direction, etc. Further analyses of air taken from many points on the Atlantic Ocean, and from the top of Pike's Peak, showed a like uniformity in composition.

No. 167. Benedict, Francis G., and Walter G. Cady. *A Bicycle Ergometer with an Electric Brake.* Octavo, iii+44 pages, 16 text figures. Published 1912. Price $0.50.

A form of stationary bicycle, in which the rear wheel is replaced by a copper disk rotating in an electro-magnetic field, has been extensively used in this laboratory for measurements of the mechanical work of man. Certain important calibration tests, friction measurements, and the peculiar magnetic reaction produced by the copper disk rotating between the poles of the magnet are described in this publication. Two instruments were used, one having been calibrated several years before. The new calibration of this latter instrument showed essentially the same values as the earlier tests. The speed usually assumed by a bicycle rider ranges from 60 to 90 revolutions per minute, and at these speeds the ergometer, singularly enough, gives essentially the same heat per revolution; at slower and higher speeds there is a marked decrease in the heat per revolution. A careful study of the magnetic reactions in the disk showed the peculiarly interesting demagnetizing effect of the eddy currents in the disk.

No. 187. Benedict, Francis G., and E. P. Cathcart. *Muscular Work: A Metabolic Study with Special Reference to the Efficiency of the Human Body as a Machine.* Octavo, 176 pages, 1 plate, 10 text figures. Published 1913. Price $2.50.

This investigation, which was carried out by means of a special form of respiration apparatus and the bicycle ergometer described in an earlier publication (Publication No. 167 of the Carnegie Institution of Washington), considers two essentially fundamental questions—first, the character of the material burned in the body before, during, and after muscular work, and second, the relationship between the amount of productive effective muscular work and the total heat output, this comparison indicating the mechanical efficiency of the human body as a machine. The investigation lasted several months and involved several hundred experiments.

It was conclusively demonstrated that during severe muscular work there is a distinct alteration in the character of the materials burned in the body, as the evidence indicated a selective combustion of carbohydrate material, though the experiments do not point to an exclusive combustion of carbohydrate during muscular work.

The major portion of the experiments was devoted to a study of the relationship between the total heat output and the effective external muscular work, thereby giving information in regard to the mechanical efficiency of man. An extensive discussion of what is meant by "gross" and "net" efficiency, together with the careful computation of the maximum efficiency, leads to an interesting discussion as to the analysis of the chemical and thermal processes involved in severe muscular work.

The report also considers other important questions relative to the muscular work of man, such as the effect of muscular work on the pulse-rate, the body-temperature, the mechanics of respiration, and the drafts upon the body material,

the maximum working capacity of man, and particularly the after-effects of work. A certain amount of evidence was available for a comparison of results obtained with trained and untrained individuals.

An extensive review of the earlier literature, with an analysis of the results obtained by former investigators, is included in the report.

No. 201. Benedict, Francis G., and Fritz B. Talbot. *The Gaseous Metabolism of Infants with Special Reference to its Relation to Pulse-rate and Muscular Activity.* Octavo, 168 pages, 65 figures. Published 1914. Price $1.50.

A complete historical review of all the literature on the gaseous exchange and calorimetry of infants is followed by a presentation of several important problems in this field. A respiration apparatus, measuring simultaneously carbon-dioxide production and oxygen consumption and provided with a sensitive arrangement for registering automatically and graphically the slightest body movement, was used to study 37 infants during approximately 800 periods of observation. Continuous records of the pulse-rate, and a graphic representation of the degree of muscular repose enabled many important correlations with the respiratory studies. Distinct evidence of an increased pulse-rate and metabolism independent of external activity was interpreted as being an indication of internal work and suggested the pulse-rate as an index of this internal work.

Particular stress was laid upon a comparative study of the basal metabolism of the infants, *i. e.*, the metabolism during complete muscular repose as shown by the kymograph records. Under these conditions, it was found that while, in general, the smaller infants had the smaller total metabolism, there were a sufficient number of striking exceptions to prevent the formulation of a definite law. Similarly, there was no uniformity in the metabolism per kilogram of body-weight, although with "normal" children the plotted chart gave indications of an approximately regular line.

A discussion of the supposed relationship between body-surface and metabolism and a critique of the methods used for measuring body-surface introduces the discussion of the values found with these infants. No relationship was found between the age of the infants and the heat produced per square meter of body-surface, nor could any relationship be noted between the heat-production per square meter of body-surface and the actual body-weight, the normal weight for the age, or the expected body-weight.

Evidence secured with normal and atrophic infants of different ages and weights is presented to show that the active mass of protoplasmic tissue determines the heat-production. This active mass of protoplasmic tissue may be stimulated to a greater or less cellular activity, the intensity of the stimulus being indicated by the pulse-rate.

No. 203. Benedict, Francis G. *A Study of Prolonged Fasting.* Octavo, 416 pages, 5 plates, 47 figures. Published 1915. Price $4.00.

In the spring of 1912 an experiment was made at the Nutrition Laboratory on a subject, A. L., who subsisted for 31 days without food, drinking during that period only 750 c.c. of distilled water per day. Observations were also made for 4 days prior to the fast and imperfect observations for 3 days subsequent to it. The main object of the investigation was to determine simultaneously as many factors in the physiology of the subject as possible. The research included physical examinations by a physician, accompanied by photographic studies and careful anthropometric measurements; records of the body-weight, rectal temperature, pulse-rate, and blood pressure; a complete daily examination of the blood; and a study of the mechanics of respiration including the ventilation of the lungs, the respiration-rate, and the alveolar air. Records of the subject's mental attitude toward the fast were kept, together with a series of psychological tests. Observations were also made of the intestinal flora and the excretion through the skin. A complete chemical examination of the urine was carried out by modern methods, which included determinations of the various nitrogenous compounds, acid and basic radicles, carbon and energy and the microscopy of the urine. An extended study

was made of the respiratory exchange, in which both the respiration apparatus and the respiration calorimeter were used, this including the study of the influence of various factors upon the respiratory exchange, such as the work of writing, of breathing oxygen-rich atmospheres, and the condition of sleeping and waking. The elimination of water through the lungs and skin was also determined. From these data important deductions regarding the total katabolism per 24 hours, the character of the katabolism, the loss of water from the body, the loss of original body substance, and the total energy loss were drawn.

The observations were carried out chiefly by the laboratory staff and with the cooperation of Drs. W. G. Anderson, J. E. Ash, H. W. Goodall, E. C. Kendall, H. L. Langfeld, and E. E. Southard. It is impossible in this brief abstract to comment intelligently upon the results which are extensive and should throw much light upon the relationship between inanition and disease.

No. 216. Carpenter, Thorne M. *A Comparison of Methods for Determining the Respiratory Exchange of Man.* Octavo, 265 pages, 74 figures. Published 1915. Price $2.50.

This publication gives the results of an extensive series of investigations upon the comparative value of a number of methods used for the determination of the respiratory exchange of man. The first part contains a review of the previous work of other investigators and a detailed description of the methods and apparatus used in the research reported, viz.: Bed respiration calorimeter; the two forms of the Benedict universal respiration apparatus, *i. e.,* tension equalizer unit and spirometer unit; Zuntz-Geppert, Tissot, and Douglas apparatus; the Haldane gas analysis apparatus; and minor accessory apparatus. The results of the various comparisons of apparatus follow. The bed respiration calorimeter was made the standard for normal respiratory exchange. The carbon-dioxide elimination, oxygen absorption, respiratory quotient, pulse-rate, respiration-rate, and, when possible, total ventilation of the lungs and volume per respiration were determined. Tables of variations and probability curves for the various determinations made are given and discussed for nearly all of the comparisons. The publication concludes with a critical discussion of the sources of error; the advantages and disadvantages of the various apparatus and methods used; breathing appliances; valves; gas-analysis apparatus; and the accuracy and interpretation of the results of the respiratory exchange of man.

No. 231. Benedict, Francis G., and H. Murschhauser. *Energy Transformations during Horizontal Walking.* 100 pages, 7 figures. Published 1915. Price $1.00.

The main object of this research was to study the increase in metabolism due to walking on a level at increasing speeds. A complete historical review is given of all previous research in which the gaseous metabolism during horizontal walking has been studied, including a large summary table in which the results of 20 different investigations are recorded and compared. Determinations were made of the carbon-dioxide production, the oxygen consumption and the distance walked by the subject; records of the respiration-rate were obtained automatically by a special tambour arrangement; a few records of pulse-rate were obtained with the Bock-Thoma oscillograph and the Einthoven string galvanometer; the exact number of steps taken were recorded automatically by a step-counter; and finally, the height to which the body was raised during walking was measured by a work-adder wheel with a scheme by which each upward and downward movement of the body was recorded upon a rotating kymograph drum.

In the walking experiments the subject walked at a very slow speed, a medium speed, or a very fast speed, and in a few experiments actually ran, thus giving data for comparing the work of forward progression while the subject was walking with that while he was running. A study was also made of the effect on metabolism of fatigue due to long-continued walking. The report concludes with an analysis of the mechanics of locomotion.

No. 232. Dodge, Raymond, and F. G. Benedict. *Psychological Effects of Alcohol. An Experimental Investigation of the Effects of Moderate Doses of Ethyl Alcohol on a Related Group of Neuro-muscular Processes in Man.* Octavo, 281 pages, 1 plate, 32 figs. Published 1915. Price $2.50.

This first publication of results under the program of the Nutrition Laboratory for an exhaustive study of the physiological consequences of the ingestion of moderate doses of ethyl alcohol in man deals with its effects on the neuro-muscular tissues with especial reference to its effects on mental processes. Responses from various levels of the nervous system from the lumbar reflex centers of the cord to the association areas of the cerebral cortex were investigated by techniques which were carefully selected for their objectivity and freedom from arbitrary interference as well as for their accurate measurement of systematically related processes. These approved techniques are carefully described; in connection with the accumulation of normal measurements, they should provide a useful base-line for any future study of experimental variations in the selected processes. The variations from normal of these several measurements, after the ingestion of alcohol doses of 30 c.c. and 45 c.c., respectively, give data for the nature and the comparative incidence of the effects of alcohol on widely different levels of the nervous system. The results of the measurements not only furnish solution to many of the outstanding problems of the psychophysiological effects of alcohol, but also serve as a basis for interpreting some troublesome discrepancies and apparent contradictions in less extensively correlated data. In conjunction with the pulse data they furnish presumptive evidence of the effect of alcohol on organic efficiency.

No. 233. Benedict, Francis G., and Fritz B. Talbot. *The Physiology of the New-born Infant: Character and Amount of the Katabolism.* Octavo, 126 pages, 10 figures. Published 1915. Price $1.00.

Investigations on infants were commenced in the hope of securing information with regard to normal infants prior to an extended pathological study. A systematic research into the metabolism of over 100 new-born infants has resulted in an accumulation of sufficient data for definite conclusions; a constant routine was rigidly adhered to in all cases, so that the results are comparable. Several hundred experimental periods were obtained. An analysis of the data for the minimum metabolism periods shows that on the first day of life there are important temperature regulation disturbances which result either in a decreased metabolism, or an increased metabolism when there is an effort on the part of the infant to compensate for the loss of heat. After the second day there is a fair uniformity in the heat-production per square meter of body-surface and a remarkable uniformity per square meter of body-surface per unit of length. This constancy is such as to permit the establishment of a factor which indicates that when the square meter of body-surface, as computed from the body-weight, is divided by the length, the metabolism per unit is 12.65 calories. From a study of the effect of temperature changes on the basal metabolism and the amount of available breast secretion the first week of life, certain procedures for the conservation of energy and supplemental feeding are suggested.

No. 84. Osborne, Thomas B. *The Proteins of the Wheat Kernel.* Octavo, 119 pages. Published 1907. Price $0.75.

This paper contains the results of the author's studies of the protein constituents of the wheat kernel. The properties and proportions of the different types of protein which can be isolated from the seed are given, and the relations of these to the proteins earlier described by others are discussed. The results of the recent analyses of the products of hydrolysis of these proteins are given in detail, and some questions regarding their nutritive value, which are raised by these analyses, are discussed. The character and proportion of the proteins of the embryo are compared with those of the endosperm. This paper aims to give as complete an account as possible of what is now known of the proteins of wheat.

No. 156. Osborne, Thomas B., and Lafayette B. Mendel. *Feeding Experiments with Isolated Food Substances.* Octavo, 53 pages, text figures i-xxi. Published 1911. Price $0.50.

Part II. Octavo, pp. iii+55-138, text figures xxii-cxxix. Published 1911. Price $1.00.

This series of publications gives the results of an investigation originally intended to secure data as to the relative nutritive value of the protein constituents of the more important food substances. Since many of the proteins differ widely from one another in their chemical constitution, an attempt is made to determine definitely to what extent these differences affect their value in nutrition. The conditions under which animals can be fed with mixtures of isolated food substances are described. Only the purest preparations of the proteins which could be made were fed in combination with carbohydrates, fats, and inorganic salts.

In Part I is given an extensive review of the literature relating to feeding animals with artificial mixtures of isolated food substances. The methods employed by the authors are described, and an account of their experience in feeding such mixtures is given. The results recorded relate chiefly to determining the conditions necessary for properly studying the rôle of the different proteins in nutrition.

Part II presents an account of feeding experiments with food mixtures containing different proteins, all of which, with the exception of zein from maize, served equally well to maintain mature animals. These data have an important bearing on the relation of amino-acids to nutrition and the extent of the synthetic processes which occur in assimilation. It is shown that while all these food mixtures, except those containing zein, maintain rats during periods of 150 to more than 200 days, they ultimately fail to meet the nutritive requirements of the animals unless a change is made in the diet.

In the course of the experiments it was found that a food containing a sufficient quantity of milk powder met all the nutritive requirements of the rats during very long periods, which led the authors to prepare a fat-free and protein-free powder from milk, which should serve as a basal ration. The addition of this substance to the food at once restored rats declining on purely artificial food and also induced normal growth in the young, irrespective of the protein of the food, with the exception of the alcoholic-soluble proteins of the cereals. The methods of feeding described furnish new means for studying many questions, not only concerning proteins in metabolism, but all the other components of food.

EXPERIMENTAL EVOLUTION, VARIATION, AND HEREDITY.

PAPERS OF STATION FOR EXPERIMENTAL EVOLUTION.

No. 23. (Paper No. 1, Station for Experimental Evolution.)

CASTLE, W. E. *Heredity of Coat Characters in Guinea-pigs and Rabbits.* Octavo, 78 pages, 6 plates, 8 figs. Published 1905. In cloth binding. Price $1.00.

This work gives the results of the author's experiments from their beginning in 1900 until the middle of the year 1904. The fundamental colors and the color patterns of guinea-pigs are for the first time analyzed; the existence of latent characters (factors, of the present time) is discovered and a case of blending character (lop-earedness in rabbits) examined. The recessiveness of albinism, of smooth coat, and of long coat are pointed out, and the imperfection of dominance in many cases is recognized.

No. 24. (Paper No. 2, Station for Experimental Evolution.)

MACDOUGAL, D. T., A. M. VAIL, G. H. SHULL, and J. K. SMALL. *Mutants and Hybrids of the Oenotheras.* Octavo, 57 pages, 22 plates. Published 1905. In cloth binding. Price $1.00.

A first study in America—the home of the evening primrose—of its relationships and the inheritance of its characters. The home of *Oenothera lamarckiana* is traced; the various native primroses are described; some of their hybrids are fully worked out and the dominance of characters considered. Further evidence of mutation in the evening primrose in new soil was forthcoming. The paper concludes with a statistical comparison by Dr. Shull of *Oenothera lamarckiana* with *nanella* and *rubrinervis*. The variation polygons in stature of *lamarckiana* and *nanella* are shown to be discontinuous, as are also those of the number of branches of *lamarckiana* and *rubrinervis*.

No. 30. (Paper No. 3, Station for Experimental Evolution.)

SHULL, G. H. *Stages in the Development of Sium cicutæfolium.* Octavo, 28 pages, 7 plates, 11 text figures. Published 1905. Price $0.25.

The hemlock or water-parsnip (*Sium cicutæfolium*) presents during development a great range of leaf form. The theory that the forms which develop earliest are ancestral is not supported by the evidence, and the conclusion is reached that the interpretation of the various forms must be physiological rather than phylogenetic.

No. 48. (Paper No. 4, Station for Experimental Evolution.)

TOWER, W. L. *An Investigation of Evolution in Chrysomelid Beetles of the genus Leptinotarsa.* Octavo, x+320 pages, 30 plates, 31 text figures. Published 1906. Price $3.25.

An extensive treatise on the group to which the Colorado potato beetle belongs, with reference to the distribution of the species, their variations, their color phenomena in general, and especially their chemistry, ontogeny, and experimental modification. The habits and instincts of these insects are discussed and an important series of pedigree cultures of modified insects is described. Finally, the bearing of these experimental results on the origin of species is considered at some length.

No. 49. (Papers Nos. 5 and 6, Station for Experimental Evolution.)

CASTLE, W. E., and ALEXANDER FORBES. *Heredity of Hair-length in Guinea-pigs, and its Bearing on the Theory of Pure Gametes.* Octavo, 10 pages, 2 figs.

CASTLE, W. E. *The Origin of a Polydactylous Race of Guinea-pigs.* Octavo, 13 pages.

Published 1906. Price $0.25

The authors discuss the result of mating guinea-pigs with long and with short hair respectively and conclude that long hair is recessive. However, in subsequent crosses, hairs of an intermediate length arose, and this condition is believed to have acted as a permanent blend of the long- and short-haired types; and the conclusion

is reached that gametic purity is not absolute. The inheritance of polydactylism in the same species indicates that there is a variation in the potency of characters dependent upon the degree of their development.

No. 52. (Paper No. 7, Station for Experimental Evolution.)

DAVENPORT, C. B. *Inheritance in Poultry.* Octavo, v+136 pages, 17 plates. Published 1906. Price $1.00.

This is a first study of thirteen sets of hybridizations between various pairs of races of poultry. The inheritance of about thirty characters is considered and a number of general topics discussed. Especial stress is laid on imperfection of dominance and on the non-dependence of the dominant character upon the races involved. The conclusion is reached that the patent form of a characteristic is dominant over its "latent" (or absent) "allelomorph."

No. 70. (Paper No. 8, Station for Experimental Evolution.)

MACCURDY, HANSFORD, and W. E. CASTLE. *Selection and Cross-breeding in relation to the Inheritance of Coat-pigments and Coat-patterns in Rats and Guinea-pigs.* Octavo, 50 pages, 2 plates, 5 text figures. Published 1907. Price $0.50.

This is a study upon the problem of mutation *vs.* continuous variation. Pigmented rats have either a uniform pigmentation; or an "Irish" pigmentation, lacking color on the middle belly; or the "hooded" pigmentation, lacking color everywhere except on the head, and sometimes also back and shoulders. The more extensive pigmentation tends to dominate in the offspring. The types appear to be definite, but they may be modified by selection and hybridization so as to produce hooded families with narrow back stripe or those with broad back stripe; and these conditions may be exaggerated in successive generations. On the other hand, selection was unable to fix a particular pattern in guinea-pigs. The conclusion is reached that "selection" is of importance in the improvement of races and that inheritance is to some extent blending.

No. 81. (Paper No. 9, Station for Experimental Evolution.)

MACDOUGAL, D. T., A. M. VAIL, and G. H. SHULL. *Mutations, Variations, and Relationships of the Oenotheras.* Octavo, 92 pages, 22 plates, 73 text figures. Published 1907. Price $1.00.

Includes a continuation of the investigations described in No. 24. The identity, distribution, and coefficient of mutability of Lamarck's evening primrose are discussed. The conclusion that newly arisen characters, such as the hypanthium, are more variable than older ones is supported by the detailed studies made by Dr. Shull, and illustrated in this paper by numerous tables and diagrams. The taxonomic and physiologic aspects of several of the mutants and of native species of *Oenothera* come in for a large share of attention. The overlapping distribution of closely related species is described. *Oenothera parviflora,* long known in the gardens in Europe, has been found in its native habitat in Maine, suggesting a similar origin for many other species. The occurrence of two bud-sports is noted, one being the mutative appearance on a branch of a recessive character in a hybrid combination. Additional experiences with the method of ovarial treatment, discovered by Dr. MacDougal in 1905, are given, and two forms secured in this manner were found to be constant to the third generation, demonstrating that new characters may arise by the action of external agencies upon the germ-plasm. Much historical matter of interest is included.

No. 95. (Paper No. 10, Station for Experimental Evolution.)

DAVENPORT, C. B. *Inheritance in Canaries.* Octavo, 26 pages, 3 plates colored to life. Published 1908. Price $0.80.

Studies on inheritance of some characters in canary birds reveal mendelian inheritance in this rather recently domesticated species. Crest dominates over its absence and perfect crest over defective. Mottling results from yellow × green and is a heterozygous character. Stress is laid upon the principle of localization of units in a complex plumage pattern.

No. 101. (Paper No. 11, Station for Experimental Evolution.)

LUTZ, FRANK E. *The Variation and Correlation of the Taxonomic Characters of Gryllus.* Octavo, 63 pages, 6 figures. Published 1908. Price $0.40.

A critical, biometric study of the species of the genus *Gryllus,* or crickets. In the genus all characters are highly variable; some, like ovipositor length, seem affected by local influences. Wing length is dimorphic and the two forms fail to intergrade. This character is studied in detail. General conclusions are drawn as to evolution and the species question.

No. 112. (Paper No. 12, Station for Experimental Evolution.)

SHULL, G. H. *Bursa bursa-pastoris and Bursa heegeri: Biotypes and Hybrids.* Octavo, 57 pages, 4 plates, 23 text figures. Published 1909. Price $0.50.

Of the common shepherd's purse only a single species is usually recognized; yet a casual acquaintance with the species shows that it is very variable. The leaves of the rosette, particularly, show many characters, of which four at least are inherited in typical fashion. One kind of leaf has attenuated lobes with a basal secondary lobe; another attenuated lobes without the basal one; a third has a short lobe with a secondary one; the fourth has the lobe both short and without a secondary one. Hybridization proves that the two conditions of both primary and secondary lobing are inherited as distinct characters, but the statistical results are often blurred by the imperfection of dominance. *Bursa heegeri* is a rare species, thought to have arisen from *bursa-pastoris* by a mutation which has resulted in an elliptical instead of a triangular seed capsule. When hybridized with *bursa-pastoris,* segregation of capsule-form occurs, but the proportion of elliptical capsules in the second hybrid generation is only 4 per cent instead of 25 per cent. Additional factors are suspected or else there is selective fertilization or survival.

No. 114. (Paper No. 13, Station for Experimental Evolution.)

CASTLE, W. E., in collaboration with H. E. WALTER, R. C. MULLENIX, and S. COBB. *Studies of Inheritance in Rabbits.* Octavo, 70 pages, 4 plates. Published 1909. Price $0.75.

This is a continuation of the series of studies upon heredity in mammals of which earlier numbers are Nos. 23, 49, and 70, of the publications of the Carnegie Institution of Washington. Heredity of ear-size in short *vs.* lop-eared rabbits is first considered. The normal rate of growth is described for both varieties and also the result of pure breeding and cross-breeding. The conclusion is reached that the cross-breeds are not only blends but the blend is permanent. Part II deals with body-weight, and the conclusion is reached that weight inheritance, like the inheritance of ear-size, is blending in character. Neither dominance nor segregation in the mendelian sense is recognizable. Part III is concerned with skeletal dimensions, which also prove to be blending characters. In Part IV, 24 pages are given to an analysis of color factors in the coat of the rabbit. This analysis is carried further than hitherto in any group of animals.

No. 121. (Paper No. 14, Station for Experimental Evolution.)

DAVENPORT, C. B. *Inheritance of Characteristics in Domestic Fowl.* Quarto, 100 pages. 12 colored plates. Published 1909. Price $4.50.

In the newer studies of heredity attention is directed to the characteristics of organisms, taken one at a time. Great diversity in the method of inheritance is found. The present work considers behavior of ten morphological characters and the principal colors of poultry. Some characters are evidently simple and are inherited in accordance with the pure Mendelian formula; others show marked deviations from it, such as "blending" and imperfect dominance. Even in such cases, however, a segregation of characters takes place in the germ-plasm. The characters analyzed in detail are the split or Y comb, polydactylism, syndactylism, rumplessness, winglessness, booting, nostril, crest, and comb-lop. The inheritance of plumage color is described, and it appears that in each color-race the plumage coloration is determined by a number of factors, the varied combinations of which account for "reversion," "sporting," and various apparent abnormalities in the reproduction of

coloration and patterns. A general discussion closes the book, in which there are considered the relation of heredity to ontogeny, the significance of dominance and recessiveness, potency, reversion and the factor hypothesis, the limits of selection, non-inheritable characters, and the rôle of hybridization in evolution. The volume is illustrated by twelve lithographic plates of plumage coloration.

No. 122. (Paper No. 15, Station for Experimental Evolution.)

JOHNSON, R. H. *Determinate Evolution in the Color Pattern of Lady Beetles.* Octavo, IV+104 pages, 92 text figures. Published 1910. Price $1.00.

A study of the life and habits, color patterns, variability, modificability, distribution, heredity, and evolution of the "lady bird" beetles, based on several years of statistical and experimental study of all the American species, including several new species and varieties. The studies on *Hippodamia convergens, glacialis,* and *spuria; Coccinella novemnotata; Adalia bipunctata* and *frigida;* and *Epilachna* are the most detailed and to the greatest extent experimental. Variation is found to be both continuous and discontinuous, with a tendency to be disposed about centers. The color pattern is modifiable by environment, and some of the modifications are inheritable characters. The distribution does not follow formulated laws of evolution by isolation. Heredity, while usually segregate, frequently gives little evidence of discrete unit characters.

No. 143. (Paper No. 16, Station for Experimental Evolution.)

LUTZ, FRANK E. *Experiments with Drosophila ampelophila, concerning Evolution.* Octavo, III+40 pages, 53 text figures. Published 1911. Price $0.50.

This paper treats of the effect of artificial and sexual selection upon abnormal wing-venation, of the characteristics of this venation, and of its inheritance. A series of experiments, in which it was found that no degeneration accompanied disuse continued for more than forty generations, is briefly discussed.

No. 144. (Paper No. 17, Station for Experimental Evolution.)

CASTLE, W. E., and J. C. PHILLIPS. *On Germinal Transplantation in Vertebrates.* Octavo, 26 pages, 2 plates. Published 1911. Price $0.50.

The authors have succeeded in two instances in transplanting the ovaries from a guinea-pig of one color variety to a guinea-pig of a different color variety, with the result that the transplanted ovaries afterward functioned in their new environment and produced living young. These resembled the animal from which the ovaries were originally taken, not the one in which the young developed. This result shows the correctness of Weismann's view that the body is merely the container of the germ-cells and in no wise determines their character. The paper contains also a critical review of the extensive literature on the transplantation of ovaries and testicles, with a bibliography of the same.

No. 179. (Papers Nos. 18 and 19, Station for Experimental Evolution.)

CASTLE, W. E. *Reversion in Guinea-Pigs and Its Explanation.* Octavo, 10 pages.

LITTLE, C. C. *Experimental Studies of the Inheritance of Color in Mice.* Octavo, 92 pages, 5 colored plates.

Published 1913. Price $2.00.

Dr. Castle's paper treats of an ancestral or atavistic coat-character of the guinea-pig, present in most wild rodents, but frequently absent in their tame varieties, and which may be obtained by crossing certain domesticated varieties of guinea-pig. A full account is given of how the reversion in question may be secured, how its reappearance can be accounted for, and in what way the recovered character may be "fixed" or reestablished as a racial character, together with the complete data which form the basis of this account.

Dr. Little analyzes the observed phenomena of color inheritance in mice, on the basis of mendelian heredity, and shows the relations of the various factors involved in the production of colors, to each other and to the coat and eye colors produced. The paper includes the analysis and description of the color factors and gives the experimental data on which the conclusions are based. Colored plates show the typical color varieties of mice.

No. 188. (Paper No. 20, Station for Experimental Evolution.)

DAVENPORT, CHARLES B. *Heredity of Skin-Color in Negro-White Crosses.* Octavo, 106 pages, 4 plates. Published 1913. Price $1.75.

The heredity of skin color in negro-white crosses is of importance for the theory of heredity and in its application to social conditions. Its theoretical significance lies in the fact that it is the last line of defense of those who deny the general validity of "Mendelism" and the modern science of heredity that has grown out of it. In skin color at least, it is asserted, we have true blending and no "segregation." This paper is based on the measurement of skin color of between 600 and 700 children, about 200 pairs of parents, and various other relatives. The result is clear cut: Skin color is inherited in "Mendelian" fashion; and segregation does take place. The evidence for this conclusion rests (1) on the fact that the color of the offspring of two strict mulattoes is much more variable than is the skin color of the hybrids of the first generation (compare table 18 with table 11), and (2) upon the fact that among the offspring of mulattoes are white and black children, who "breed true" to their respective colors. The apparent blend that has long been recognized in skin color is due to the large number of factors that produce negro skin color.

Studies are made into special phases of the question of inheritance of skin color. The development of pigmentation in the child is considered; the fact that even a negro child is born relatively white, and does not attain full pigmentation until puberty, complicates the main investigation. There is no difference in the skin color of adult negro men and women, and the color of the mulatto children is the same whether the father or the mother is the white parent. The tradition that a woman who passes for white may have by a Caucasian consort a black child receives from these studies no confirmation and is probably false; on the other hand, a "light colored" pair may have children who are much darker than either parent.

Data were studied relative to eye color, hair color, and curliness of the hair. The grades of eye color are numerous; the darkest browns are duplex in nature, *i. e.*, receive the determiner for brown from both parents; the hazel and many lighter browns are simplex in origin, or heterozygous. In hair pigmentation many factors are involved. In general the hair of the children is not darker than that of the darker parent. As for curly hair, it dominates over straight; and the curlier types (frizzly, woolly) dominate over the less curly.

Certain social applications of this study are drawn. There is no correlation, in the children of mulattoes, between the color of the skin and the curliness of the hair. It is proper to infer that many other physical and many mental characteristics of the negroes are not necessarily associated with the color of the skin. It is quite possible that there may be derived, in later generations, from a negro × white hybrid, not only a white person with Caucasian mentality but also a black-skinned person with Caucasian mentality and moral traits.

There is also no foundation for the view that hybrids are less fertile than the pure races. Some of the most fecund families of Jamaica are those of mulattoes.

No. 195. (Paper No. 21, Station for Experimental Evolution.)

CASTLE, W. E., and JOHN C. PHILLIPS. *Piebald Rats and Selection: An Experimental Test of the Effectiveness of Selection and of the Theory of Gametic Purity in Mendelian Crosses.* Octavo, 56 pages, 3 plates. Published 1914. Price $0.75.

The hooded pattern of tame rats behaves as a recessive Mendelian unit-character in crosses with other color varieties of rat. In the second generation from such a cross, one-fourth of the offspring are hooded. Notwithstanding the behavior of the hooded pattern as a clearly segregating unit in heredity, the unit is slightly modified by crosses. It may also be modified by "mass-selection" unattended by crossing. Twelve generations of selection in opposite directions (plus and minus) from a stock of hooded rats has produced races widely different in pattern. Return selection toward the original racial condition progresses at the same rate as the departure from that condition had occurred. This, with the gradual disappearance of regression upon repeated selection, shows the effects of selection

to be permanent. Upon crossing the selected races with each other an intermediate condition is obtained which in the following generation shows increased variability about the same intermediate condition. Crossing the plus selected race with wild rats renders it less plus when extracted in the second filial generation. Crossing the minus selected race renders it less minus. These seemingly contradictory results and other results described in this paper favor a hypothesis that the immediate effect of selection is registered in the germ cell, not along with the chief determiner of the hooded pattern but independently of it. But ultimately, and as an indirect result of selection, the accumulated effects of the selection become in some way incorporated in the same single unit, when a simple Mendelian behavior is observed. On this view mass-selection is an effective means of guiding evolution not only by the cumulation of small variations but also by inducing "mutation." These conclusions are based on the study of more than 25,000 rats bred in the course of seven years. The observations are summarized in some fifty correlation tables in which parents and offspring are compared as to the extent of their pigmentation.

No. 196. (Paper No. 22, Station for Experimental Evolution.)

MacDowell, E. C., and W. E. Castle. *Size Inheritance in Rabbits.* Octavo, 55 pages, 9 figures. Published 1914. Price $0.50.

In the historical part of this paper a review is made of all accessible previous observations on size inheritance in animals and plants with a view to ascertain whether evidence of Mendelian segregation as regards size characters can be detected. In the experimental part is described an extensive series of experiments with rabbits in which crosses were made between small-sized and large-sized rabbits. The immediate offspring were in nearly all cases found to be of intermediate size, as were also offspring of a second filial generation (F_2), but this second generation was in most cases found to be more variable than the preceding one, which fact the author regards as evidence of the presence of size-determiners which mendelize in crosses but without the occurrence of dominance. In an appendix, it is shown that a high degree of correlation exists within the body between one skeletal measurement and another, and the fact is pointed out that if size-determiners exist they are general in character and affect all parts of the skeleton simultaneously.

No. 205. (Paper No. 23, Station for Experimental Evolution.)

Detlefsen, J. A. (with prefatory note by W. E. Castle.) *Genetic Studies on a Cavy Species Cross.* Octavo, 134 pages, 10 plates, 2 text figures. Published 1914. Price $2.00.

Cavia rufescens, a distinct species of wild Brazilian guinea-pig, was crossed with *C. porcellus,* the tame domestic guinea-pig. The female hybrids were fertile, but the male hybrids were sterile. The female hybrids were crossed back to males of both parent species, the cross with guinea-pig males being more successful. By eight successive back crosses to guinea-pig males, more and more dilute wild-blooded generations were obtained. Over 1,800 animals of the various hybrid generations were thus produced. Part I, dealing with color and coat characters, shows that they are transmitted in accordance with Mendel's law. Any combination of characters possible in the guinea-pig is possible in the hybrids. Although acting as units in transmission, several characters were modified in the cross. Part II discusses growth and morphological characters in the parent species and hybrids. The guinea-pig is apparently dominant in size, but segregation was not apparent. The M-shaped nasal-frontal suture of the wild was dominant to the truncate suture of the tame. The later hybrids showed a great range of variation. Morphological anomalies occurred in the hybrids. Part III deals with fertility of the parent species and hybrids. The peculiar sterility in the male hybrids seems to be due to multiple factors (possibly about 8), the elimination of which gives recessive fertile males. The sex ratio in the early hybrid generations showed a marked excess of females. The wild females have a smaller litter-average. The hybrid females are intermediate, but back-crosses to guinea-pig males gradually raised this average.

No. 236. (Paper No. 24, Station for Experimental Evolution.)

DAVENPORT, C. B. *The Feebly Inhibited: Nomadism or the Wandering Impulse with Special Reference to Heredity. Inheritance of Temperament.* Octavo, 158 pages, 89 figs. Published 1915. Price $1.50.

The present volume includes two in a series of studies upon the feebly inhibited. The first part has to do with nomadism and includes the results of the study upon the records of 100 families, one or more members of which have shown a tendency to run away from home, families, and duties, or to engage in a nomadic occupation. In these families, out of 186 nomadics, only 15 are females. The hypothesis that best fits the facts is that nomadism is a sex-linked trait. There is no clear case of a nomadic daughter whose father is known to be non-nomadic. All daughters, therefore, of two nomadic parents are nomadic. The criterion that half of the daughters and half of the sons of nomads in varying fraternities derived from nomadic fathers are themselves nomadic is satisfied so far as sons go, less abundantly for the daughters. In general, the history shows that nomadic fathers may have no nomadic sons; nomadic mothers ordinarily have nomadic sons. Thus the hypothesis is supported by the facts, allowing for a certain influence of cultural conditions, which may have a strengthening effect upon the development of weak natural inhibitions.

The second part deals with the inheritance of temperament—a subject which Galton discussed 30 years ago. The facts that have to be met are the great diversity of temperament, some persons being prevailingly gay, others prevailingly somber, while others pass through alternating cycles of elation and depression. For a test of the hypothesis 89 carefully described family histories were available and these afforded 147 matings in which the mated pair, their parents (usually), and certain of their offspring were sufficiently described for the purposes of the test. The hypothesis involves a difference in the method of inheritance of extreme hyperkinesis (a dominant) and extreme hypokinesis (a recessive). Thus some of the differences of opinion that have arisen concerning the method of inheritance of manic depressive insanity is accounted for. Especial attention is paid to the inheritance of temperament as seen in identical twins and to the temperamental condition that permits suicide. A further consideration of the whole subject leads to a recognition of a dualism that runs through the population of the romantic and classic types of reaction, the feebly inhibited and the strongly inhibited.

No. 240. (Paper No. 25, Station for Experimental Evolution.)

ESTABROOK, A. H. *The Jukes in 1915.* Quarto. In press.

When Richard L. Dugdale prepared the history of "The Jukes," about 40 years ago, it was the first extensive study of the kind that had been made; and although numerous similar studies have since been made, it remains preeminent. Owing to the rediscovery, three years ago, of Mr. Dugdale's original notes giving the name and location of the persons upon whom the study was based, it became possible to bring the history of the family down to the present time and Dr. Arthur H. Estabrook, who had worked upon "The Nams" in New York State, was selected to do the field work. It was soon found that on account of economic conditions the Jukes had been largely dispersed from their original habitat, so that the study has thrown light upon the consequences of the scattering of a feeble-minded, criminalistic community. One is able, also, to compare the frequency of consanguineous marriages at present with that of an earlier time and also to compare the products of out marriage with those of close inbreeding. The present study throws light, moreover, upon the consequences of bringing children of poor heredity at an early age into better environmental conditions than their homes could ordinarily afford. This study traces the development of some good branches of the family and inquires into their origin. By combining the two studies made 40 years apart it has been possible to get a nearly complete history of seven, and in part of eight, generations. The present study is the most extensive and the most prolonged of all studies that have been made on cacogenic strains.

No. 241. (Paper No. 26, Station for Experimental Evolution.)

CASTLE, W. E., and S. G. WRIGHT. *Studies of Inheritance in Guinea-Pigs and Rats.* Octavo. In press.

An Expedition to the Home of the Guinea-Pig and some Breeding Experiments with Material there obtained. By W. E. CASTLE.

An Intensive Study of the Inheritance of Color and of Coat Characters in Guinea-Pigs, with especial reference to Graded Variations. By SEWALL G. WRIGHT.

Further Studies of Piebald Rats and Selection, with observations on Gametic Coupling. By W. E. CASTLE.

This paper contains an account of the life-history of a small species of cavy (supposed to be the ancestor of domesticated guinea-pigs) found in the vicinity of Arequipa, Peru, together with an account of hybridization experiments between this and other races of cavy obtained in the same general region. The growth rates of different races are compared, and it is found that they involve complete blending as regards size inheritance, with a physiological increase of size in F_1 not due to heredity and which accordingly does not persist beyond the F_1 generation. Inheritance formulæ are worked out for the various characters studied and an analysis is made of cases involving multiple allelomorphs as well as supplementary and modifying factors.

No. 243. (Paper No. 27, Station for Experimental Evolution.)

GOODALE, H. D. *Gonadectomy in Relation to the Secondary Sexual Characters of Some Domestic Birds.* Octavo. In press.

OTHER PAPERS RELATING TO ORGANIC EVOLUTION.

No. 25. Gulick, J. T. *Evolution, Racial and Habitudinal.* Octavo, xii+269 pages, 5 plates. Published 1905. Price $1.00.

Gives many facts concerning divergence of varieties and species distributed in more or less isolated districts, presents an analysis of the factors of both racial and habitudinal evolution, and shows that there is constant interaction between these classes of factors, and also between the autonomic and the heteronomic factors. It shows that even in the case of invertebrate animals acquired habits, produced by social evolution, often determine the form of selection, and so have an important influence on the innate (*i. e.,* racial) characters that are permitted to survive; that members of the same species exposed to the same environment in isolated groups will often arrive at different methods of dealing with the environment, and so subject themselves to divergent forms of selection; and that the power of accommodation to sudden changes in the environment sometimes saves the group from extinction, till "coincident variations" have time to arise, giving complete adaptation to the new conditions, through what may be called *coincident selection.*

In Chapter III, and near the last chapter, attention is called to the fact that all forms of life differ from the inorganic world in that they possess the power of discriminative and anticipatory action, tending to secure survival through adaptation to conditions, and that in their very nature the individuals of any group are interdependent and must cooperate if the group survives; therefore, in the degree of cooperative, discriminative, and anticipatory action in any group is found the test of the stage of evolution reached by that group.

In Chapter VI and in Appendix II are discussed the methods of constructing and of using the Permutational Triangle, which presents, in mathematical form, the fact that infertility of crosses and other forms of incompatibility between different species would tend to the extinction of life, unless accompanied by positive segregation, which brings together individuals of the same species.

No. 11. Newcomb, Simon. *A Statistical Inquiry into the Probability of Causes of the Production of Sex in Human Offspring.* Octavo, 34 pages. Published 1904. Price $0.25.

The above paper is an attempt to apply a rigorous theory of probable inference to questions of genetic biology, taking statistical data as the basis of the inquiry. The author in this case strayed outside his professional field and undertook this work with the belief that the treatment of statistical data generally on a large scale by the methods of probable induction would lead to important results to the science of the future and to conclusions on questions which elude all direct investigation. Among the topics discussed are "Preponderance of male births," "Is the ratio of male to female births the same in all races?" "Inquiry whether any unisexual tendency exists among parents," "Unisexual tendency in multiple births," "Processes suggested by the statistics of multiple births," "Influence of the age of the parent on sex," "Supposed influence of other conditions," "Mathematical theory of the effect of unisexual tendency."

No. 36. Stevens, N. M. *Studies in Spermatogenesis.*

Part I. *Studies in Spermatogenesis, with especial reference to the "Accessory Chromosome."* Octavo, 32 pages, 7 plates. Published 1905. Price $0.25.

Part II. *A Comparative Study of the Heterochromosomes in Certain Species of Coleoptera, Hemiptera, and Lepidoptera, with especial reference to sex determination.* Octavo, 33-74 pages, 8 plates. Published 1906. Price $0.25.

Part I is a comparative study of the spermatogenesis of *Termopsis angusticollis, Stenopelmatus sp.* (?), *Blatella germanica,* and *Tenebrio molitor.* Na "acessory" was found in *Termopsis.* Further study of more favorable material of *Stenopelmatus* has shown the spermatogonial number of chromosomes to be 47 (instead of 46), and the numbers in the second spermatocytes to be 23 and 24. In the account of the spermatogenesis of *Tenebrio molitor* it was determined that the chromosomes

of the oögonia and somatic cells of the female may differ in number or size from those of the corresponding cells of the male.

Part II comes along the line of investigation suggested by the study of *Tenebrio molitor*. The spermatogenesis of 18 species of Coleoptera, in which an unequal pair of heterochromosomes is found, is described, and also 4 species which have an unpaired heterochromosome. In every case where it was possible to study the chromosomes of the female, an equal pair of heterochromosomes was found corresponding to an unequal pair of an unpaired heterochromosome in the male.

No. 51. STEVENS, N. M. *Studies on the Germ-cells of Aphids.* Octavo, 28 pages, 4 plates. Published 1906. Price $0.25.

This is a comparative study of the germ-cells of 22 species of aphids, showing great variety in number and size of chromosomes in the various species. No reduction in number of chromosomes was found in the parthenogenetic eggs, which always showed a pair of chromosomes corresponding to each chromosome of the spermatocytes or polar spindles. No heterochromosomes were found, but it has since been determined that the "lagging" chromosome described in this paper is an unpaired heterochromosome, and that the spermatocytes which do not contain a heterochromosome degenerate and only "female-producing" spermatozoa mature.

No. 19. ENTEMAN, WILHELMINE M. *Coloration in Polistes.* Octavo, 88 pages, 6 colored plates, 27 text figures. Published 1904. Price $1.00.

A study of one of our commonest wasps, dealing with the variations of its colors and color pattern, the ontogenesis of the color pattern, and the geographic distribution of the types of color marking. All of these facts are considered in relation to the various theories of evolution.

No. 67. BANTA, A. M. *The Fauna of Mayfield's Cave.* Octavo, 114 pages, 2 plates, 13 text figures. Published 1907. Price $0.50.

This paper represents the results of a detailed study of the fauna of a small cave, observing its animal inhabitants throughout the year and in all conditions to which they are normally subjected. Mayfield's Cave, about 4.5 miles from Bloomington, Indiana, was selected for observation. The temperature and air-currents were observed. Collections were made, habits of the various species noted, and life histories worked out as far as possible. A bibliography at the end of the paper gives an index of the work done heretofore on the cave animals of North America.

No. 58. PEARL, RAYMOND. *Variation and Differentiation in Ceratophyllum.* Octavo, 136 pages, 2 plates, 26 figures. Published 1907. Price $1.00.

No. 64. PEARL, RAYMOND, and A. B. CLAWSON. *Variation and Correlation in the Crayfish, with Special Reference to the Influence of Differentiation and Homology of Parts.* Octavo, 70 pages, 8 text figures. Published 1907. Price $1.00.

The purpose of this study is to attempt, by the use of appropriate biometric methods, to determine the part played by such factors as position, degree of differentiation, and serial homology within a series of generally "like" parts of an organism in determining the degree of inter-correlation displayed in the variation of such parts. The fresh-water crayfish, *Cambarus propinquus* Girard, furnished the material for the work, and the joints of the ambulatory appendages afforded the series of "like" parts studied. The general result of the study is to show that, as compared with physiological factors, morphological relationship is practically a negligible factor in influencing degree of correlation between parts.

No. 104. EIGENMANN, CARL H. *Cave Vertebrates of America: A Study in Degenerative Evolution.* Quarto, IX+241 pages, 31 plates, and 72 text figures. Published 1909. Price $5.00.

This publication gives accounts of the nature of cave environment and the adaptations of cave animals to it; the habits of cave animals; a theory of the origin of the cave fauna; the structure of the eyes of cave and the other blind vertebrates; the development and later history of the eyes of the blind fish *Amblyopsis;* the Cuban blind fishes and their eyes; and a consideration of the process and the cause of the individual and phyletic degeneration of the eyes of cave vertebrates.

No. 142. Long, J. A., and E. L. Mark. *The Maturation of the Egg of the Mouse.* Octavo, vi+72 pages, 7 plates, 7 figures. Published 1911. Price $1.50.

In this paper it is shown that the mouse does not present an exception, as formerly supposed, to the rule that in maturation two polar cells are formed. By means of apparatus specially devised, accurate records of the time of parturition were secured, and a complete series of early stages obtained. The time of fertilization was controlled by artificial insemination. It is shown that the whole process of maturation is completed in from 4 to 15 hours, viz., during a period extending from about 14 hours to about 29 hours after parturition; that ovulation may occur at any time during that period, usually when the egg exhibits the first polar cell and the second maturation spindle; that *all* eggs from the first polar cell, and that all eggs which are penetrated by a spermatozoön, also abstrict the second polar cell. The apparent exception to the rule is believed to be due to the overlooked fact that the first polar cell may degenerate, thus leaving only the second polar cell, which has been mistaken for the first.

No. 228. Crampton, Henry E. *Studies on the Variation, Distribution, and Evolution of the Genus Partula: The Species Inhabiting Tahiti.* Quarto. In press.

The genus *Partula* comprises certain terrestrial snails in Polynesia, Micronesia, and Melonesia, which are relatives of the classic Achatinellidæ of the Hawaiian Islands. The present monograph is an exhaustive analysis of the species inhabiting Tahiti—the largest member of the Society Islands—on the basis of material collected by the author during four journeys, from 1906-1909. Of the many problems investigated, the most fundamental is concerned with the relative value of congenital and external factors in the differentiation of the species under consideration. The geographical, biological, and meteorological features of the Polynesian realm are described in detail, as a basis for the determination of the subservience of the snails to environmental influences. Then follows a special description of Tahiti, and of the sixty separate areas from which the many thousands of individuals were taken.

In the main body of the volume each of the six important species is described and analysed, and by the employment of statistical methods colonial differentia are brought to light which would otherwise escape detection. The peculiar features of the description, variation, and genetic relations are emphasized in every case. In briefest form the general results are as follows: (1) The snails are far from uniform in their distribution; with only one exception each group of islands has its own characteristic species which occur nowhere else. (2) The same correlation between geographical and specific discontinuity is displayed by the species of the different islands of one and the same group, for each member possesses distinct species not found in the others, although in a very few instances important exceptions occur which throw much light upon the processes of dispersal and migration as well as upon certain geological relations. (3) As in the Achatinellidæ, the species of *Partula* may vary from valley to valley of an island; a form sometimes extends over a wide range, while another may be restricted to a few valleys or even to one; less frequently differences are displayed by types which inhabit different parts of one valley. Statistical results prove the essential difference of races belonging to a species that has been heretofore regarded as invariable, while in other cases close relationships have been established for species previously considered as separate. The study of the relations between young and parent snails is of the highest importance in establishing these results. (4) The abundant material, taken in connection with the results of Garrett, gives astonishingly clear evidence of a recent origin of some types where it is possible also to determine their parentage and rate of dispersal when this has occurred, as well as the fixity of the new characteristics. (5) Mutation has been demonstrated in numerous instances, and in many species belonging to several islands. so that it can not be regarded as a unique process. (6) The influence of the "environment" seems to be little or nothing. Isolation proves to be a "condition" and not a "factor" in the differentiation of forms belonging to the genus *Partula.* (7) A result with

a wider scientific bearing is established by the comparison with one another of the snail populations of islands of the same group and of the species of different groups. All the evidence goes to show that the dominant geological process in South Pacific regions has been one of subsidence, which has progressively isolated various mountain ranges previously connected so that they have become separate island-masses, which in their turn have been subsequently converted into the disconnected islands of the several groups.

No. 237. Morgan, T. H., and C. B. Bridges. *Sex-linked Inheritance in Drosophila.* Octavo. In press.

An account of 36 sex-linked mutations in *Drosophila ampelophila,* of which 15 are described here for the first time. The numerical data (obtained in the experiments upon the linkage relations of the factors for these mutations) furnish the material by means of which the location of the factors in the sex chromosome is determined. A compilation of all the previously published data on the interlinkage of the sex-linked factors was made and on the basis of all the available data a new map of the location of the factors in the X chromosome is constructed. An introduction points out how the Mendelian ratios and the peculiar distributions seen in linkage are explicable by means of the chromosome mechanism and states the argument for the chromosome theory of heredity, especially with relation to the inheritance of sex-linked characters and the determination of sex; some of the latest evidence for this theory is given in the discussion of non-disjunction of the sex chromosomes, and some of the general methods of procedure in working with sex-linked characters, such as balanced viability, are explained. Other general subjects discussed are the determination of multiple allelomorphism; the detection of sex-linked lethals; the formation of polymorphic races; sterility; and the influence of the environment. Explanations are given of the nomenclature followed, and of the procedure used in calculations of cross-over values and chromosome loci.

STEREOCHEMISTRY APPLIED TO BIOLOGY.

No. 116. Reichert, Edward T., and Amos P. Brown. *The Differentiation and Specificity of Corresponding Proteins and other Vital Substances in Relation to Biological Classification and Organic Evolution: The Crystallography of Hemoglobins.* Quarto, xix+338 pages, 100 plates, 411 text figures. In cloth binding. Published 1909. Price $9.00.

This work is designed to show that corresponding proteins and other organic vital substances differ in chemical constitution, and that these differences are definitely related to genera, species, etc., and thus establish a principle which may prove of great importance in the explanation of heredity, mutations, the influences of food and environment, the differentiation of sex, and in other problems of biology, normal and abnormal. Differences in corresponding substances are shown to offer a new and important method in the study of the relationships of genera and species, and in general to indicate extremely important applications of stereochemistry to protoplasmic processes and products.

The volume embodies the results of the detailed crystallographic studies of the hemoglobins of 107 species, mostly mammals, including representatives of Pisces, Batrachia, Aves, Marsupialia, Edentata, Sirenia, Ungulata, Rodentia, Otariidæ, Phocidæ, Mustelidæ, Procyonidæ, Ursidæ, Canidæ, Felidæ, Viveridæ, Insectivora, Chiroptera, and Primates; also a considerable amount of incidental matter, embracing a consideration of the alliance between chlorophyll and hemoglobin; the distribution of hemoglobin, hemocyanin, and other respiratory substances among the animal kingdom; the general chemical and physical characters and specificities of the hemoglobins of different species; the specificity of the blood, as regards its various constituents, in relation to zoological classification; method for preparing, examining, measuring, and differentiating the hemoglobin crystals from different species, etc.

Exceptional crystallographic interest and value are attached to the results of this research because chiefly of the hemoglobins constituting an extraordinary isomorphous series; of the description not only of almost every known kind of twin, but also of forms of twinning entirely new and of unusual interest; and of the profuseness and accuracy with which the various crystalline forms have been illustrated by line drawings and photomicrographs.

No. 173. Reichert, Edward T. *The Differentiation and Specificity of Starches in relation to Genera, Species, etc.: Stereochemistry applied to Protoplasmic Processes and Products, and as a strictly Scientific Basis for the Classification of Plants and Animals.* Quarto, in two parts. Published 1913. Price $16.00.

Part I. The Starch-Substance and Starch-Grain. Pages i-xvii+1-342, 102 plates containing 612 photomicrographs, charts A-J.

Part II. The Differentiation and Specificity of Starches. Pages i-xvii+343-900 and 400 charts.

This research is in the nature of a preliminary investigation, and is supplementary and complementary to Publication No. 116. Previous investigators found that starch-grains exist in a considerable variety of forms, and that while the histological peculiarities of a given starch may sometimes be characteristic of the species or genus it would be hazardous to depend upon them generally as indicating the plant-source. In this research it has been demonstrated that starches from different plants vary in their physical and physico-chemical properties, and that the differences are distinctive of the plant and can be plotted out in the form of reaction-curves which give pictures, as it were, by means of which varieties, species, and genera can be distinguished and classified.

In Part I, the first chapter gives, among various topics presented, a brief statement of the crystalline nature and of the conditions which influence the form of the starch-grain, with the object of showing that histological differences do not necessarily imply any inherent differences in the constitution of the starch *per se*. Especial attention is given to the recent developments of stereochemistry, many

instances being cited to show that not only may complex organic substances exist in a number of stereoisomeric forms, but also that (in accordance with the modifications in the arrangements of the elements, groups, or masses of the molecules of corresponding substances) there are associated related dependent differences in physiological, toxicological, or other properties. Evidence is given which leads to the deduction that starch may exist in countless stereoisomeric forms, each having distinctive properties. Subsequent chapters contain descriptions of the starch-substance and the structure, form, and mechanism of formation of the starch-grain; of peculiar kinds of starch and starch-like bodies; of the primary and reverted decomposition products of starches, including references to the processes involved in giving rise to them, and to the various forms of dextrins and sugars and unusual products; and of assumed processes in the synthesis of starch. Then are given the methods heretofore used to differentiate starches and a consideration of the digestibility of raw and boiled starches, with especial reference to certain popular misconceptions regarding the latter. A chapter is devoted to quotations of histological descriptions of over 1,200 starches obtained from an exceedingly large variety of plants and plant-parts. The final chapters embrace statements of the methods employed in the investigation and the demonstration of the differentiation and specificity of starches in relation to genera, species, etc., as shown by the results recorded. Included in Part I are the plates and an index of the starches.

Part II comprises the laboratory records of the histological, physical, and physico-chemical properties of over 300 starches, representing 105 genera and 34 families, which serve as the basis of the research, including 10 text charts of reaction-intensities and an index of the starches.

The general conclusion reached from the results of these two researches is that corresponding complex organic metabolites (such as proteins, starches, glycogen, fats, cholesterins, etc.) are modified specifically in relation to genera, species, etc., and that, as a corollary, differences in the properties of such corresponding stereoisomers constitute a strictly scientific basis for the classification of plants and animals and also offer a logical basis for the study of those structural, chemical, and physiological properties of protoplasm which have their expression in heredity, mutations, variations, sex, and a host of problems of normal and abnormal biology, general and special.

BOTANY.

No. 8. Farlow, W. G. *Bibliographic Index of North American Fungi.* Octavo, Vol. 1, part 1, xxxv+312 pages. Published 1905. Price $2.00.
Vol. 1, part 2, and vol. 2.

A compilation of the references to species of fungi in North America southward to the Isthmus of Panama, and including the West Indies. About one-fourth of this projected work was issued in 1905, and no definite statement can be made as to the appearance of the remainder.

No. 15. Mottier, D. M. *Fecundation in Plants.* Octavo, viii+187 pages, 75 text figures. Published 1904. Price $1.50. (Out of print.)

The subject of fecundation in plants is presented by a discussion of the more thoroughly investigated concrete cases.

No. 6. Coville, F. V., and D. T. MacDougal. *Desert Botanical Laboratory of the Carnegie Institution.* Octavo, vi+58 pages, 29 plates. Published 1903. Price $0.50.

A discussion of the general features of deserts with respect to the climate and soil formations, together with a presentation of the principal problems presented by the specialized forms of plants which characterize arid areas. Detailed descriptive sketches are given of the arid regions in western Texas, the sand dunes of Chihuahua, the Tularosa desert, Nogales, Torres, Guaymas, the Colorado and Mohave deserts, the Grand Canyon of the Colorado, and the Tucson region.

No. 99. MacDougal, D. T. *Botanical Features of North American Deserts.* Octavo, 115 pages, 62 plates, 6 figures. Published 1908. Price $1.75.

The more important features of deserts in North America from the Great Basin in Nevada to southern Mexico are described and amply illustrated. The initial investigations by the members of the staff of the Desert Laboratory in the Salton Basin are given, as well as various other physiological and geographical researches. Especial attention is given to the Tucson region, the geology of which was contributed by Prof. W. P. Blake. Some consideration is also given to soils, temperatures, conditions contributory to deserts, and environmental relations of desert plants.

No. 24. MacDougal, D. T., A. M. Vail, G. H. Shull, and J. K. Small. *Mutants and Hybrids of the Oenotheras.* (Paper No. 2, Station for Experimental Evolution.) Octavo, 57 pages, 22 plates. Published 1905. Price $1.00. (Out of print.)

An account of cultural investigations of the evening primroses for the purpose of testing the recurrence and stability of mutants, and an estimation of their fluctuating variability compared with the parental type.

No. 81. MacDougal, D. T., A. M. Vail, and G. H. Shull. *Mutations, Variations, and Relationships of the Oenotheras.* (Paper No. 9, Station for Experimental Evolution.) Octavo, 92 pages, 22 plates, 73 text figures. Published 1907. Price $1.00.

Includes a continuance of the investigations described in No. 24. The identity, distribution, and coefficient of mutability of Lamarck's evening primrose are discussed.

No. 141. MacDougal, D. T., and E. S. Spalding. *The Water-balance of Succulent Plants.* Octavo, iv+77 pages, 8 plates, 16 text figures. Published 1910. Price $1.00.

This book contains the results of several years' measurement of various cacti by which their form-alterations and growth were apprehended. The massive bodies of *Carnegiea, Opuntia,* and *Echinocactus* undergo alterations in volume and form with the increase or decrease of the soil-moisture and evaporation, these changes being modified to some extent by insolation and air-temperatures. The external folds of *Carnegiea* (the tree cactus) and *Echinocactus* (melon cactus) allow rapid

expansion and contraction of their great trunks, and observations upon these movements for several years are given. The results of variations in the amount and composition of the water-balance carried by desert plants are also shown. The depletion of the water-balance is accompanied by reversible changes of form; its repletion may or may not be accompanied by irreversible growth alterations. The osmotic activity of the sap and its content of mineral salts and organic matter are increased with a lowered water-balance, but the acidity remains practically unchanged. Succulents are regarded as representing the highest type of specialization under arid conditions. A speculative consideration is given to the origination and evolutionary development of these forms.

No. 129. MacDougal, D. T., and W. A. Cannon. *The Conditions of Parasitism in Plants.* Octavo, III+60 pages, 10 plates, 2 text figures. Published 1910. Price $1.00.

A description is given of the newly discovered parasitism of *Krameria canescens* and *K. parvifolia,* with details of the relations of the parasite to its principal hosts. The more important features of structure and the results of some experimental tests of the action of the parasite are set out. Cannon adds a tenth family of plants to the list of parasites among the higher plants. The results of an experimental analysis of parasitism are given. Regenerated cuttings of a number of desert plants were inserted in the bodies of cacti and other succulents, upon which many were successfully grown as xeno-parasites. Chemical analysis of the sap of the plants reveals the fact that a higher osmotic activity is necessary to enable one form to become parasitic upon another, but the actual assumption of dependent relations may be prevented by many things, such as excretions and vigorous formation of scar-tissue.

No. 117. Cannon, W. A. *Studies in Heredity as Illustrated by the Trichomes of Species and Hybrids of Juglans, Oenothera, Papaver, and Solanum.* Octavo, III+67 pages, 10 plates, 20 figures. Published 1909. Price $0.75.

A cytological study of the origin, development, variations, and inheritance of the hairs of several plants, chiefly for the purpose of determining whether or not the hairs or systems of hairs borne by a plant might be considered as unit characters. When two plants were hybridized which bore the same types of hairs but of different dimensions, the hybrid resulting showed intermediate organs, but a distinct type borne by either parent was transmitted unchanged, or as an indivisible unit character.

No. 131. Cannon, W. A. *The Root Habits of Desert Plants.* Octavo, 96 pages, 23 plates, 17 text figures. Published 1911. Price $1.50.

The results of a study of the root habits of representatives of the principal types of desert species are given in detail in this contribution. Among these forms it is found that the general aspect of the root-system is characteristic, and that, like the shoot, modifications induced by environmental agencies lie within well-defined limits. This range of variation being thus comparatively narrow, a high degree of specialization in habitat results in desert soils. The root-systems of the rapidly growing summer annuals of the desert are different from those of winter annuals in showing a fuller development of all components, but neither type penetrates the soil to a greater depth than 20 cm. (8 inches). Perennials have three types of roots, namely, the generalized type, with the tap-root and the laterals both well developed, and the specialized forms, of which one type has a prominent tap-root and the other prominent laterals. *Covillea tridentata* and *Prosopis velutina* are representatives of plants with generalized roots, while *Kœberlinia spinosa* and a few other plants have specialized roots of the second type.

No. 178. Cannon, W. A. *Botanical Features of the Algerian Sahara.* Octavo, VI+81 pages, 37 plates. Published 1913. Price $2.50.

This report gives the more important observations made by the author in the autumn of 1910 and early spring of 1911 in southern Algeria, and interprets the main characters of the flora in the light of results previously attained at the Desert Laboratory at Tucson, Arizona. The territory visited was from Laghouat, just south of

the Saharan Atlas Mountains, across the regions of the Daya and the Chebka, to Ghardaia, the chief city of the M'Zabites. From Ghardaia the Gantara was crossed to Ouargla, and thence the route followed was by Touggourt and the Oued Rirh to Biskra. Special attention is given to the root habits of the shrubs and semi-shrubs which are related so far as possible to the environment. A portion of this region visited has been little seen by botanists, and the descriptions of plant habits and their habitats are thus far new. The study is illustrated by many detailed and general pictures of plants and of their environment.

No. 98. { CANNON, W. A. *The Topography of the Chlorophyll Apparatus in Desert Plants.* Octavo, 42 pages, 15 text figures, 5 plates. / KNOX, ALICE A. *Induction, Development, and Heritability of Fasciations.* Octavo, 20 pages, 1 text figure, 5 plates. } Published 1908. Price $0.75

(*a*) The results of a developmental study of the chlorophyll apparatus of a number of species characteristic of southwestern deserts. Essentially different mechanical arrangements and functional specializations are found in species with reduced leaves and those with extensive, deciduous, laminar formations. The conditions governing the thickness and duration of chlorophyllaceous layers in organs subject to secondary thickening are analyzed and some interesting arrangements in succulents and green stems described.

(*b*) A morphological study based upon living material, showing the principal anatomical features in a number of types of fasciations, together with the results of some extensive experimental observations upon their induction. The heritability of the structures in question was tested by pedigree cultures through several generations.

No. 140. CAMPBELL, DOUGLAS H. *The Eusporangiatæ: The Comparative Morphology of the Ophioglossaceæ and Marattiaceæ.* Quarto, VI+229 pages, 13 plates, 192 text figures. Published 1911. Price $4.00.

This memoir is a study of the comparative morphology of two orders of ferns which are sometimes known as the Eusporangiatæ. These are probably the most primitive of living ferns, and a thorough knowledge of their morphology is essential for a complete understanding of many fossil types, as well as for a clear comprehension of the relationships existing between the living ferns. The object of the investigations here presented was to make a thorough study of the developmental history of as many of the living genera as could be obtained. To this end extensive collections were made by the writer in various parts of the world, and much of the material presented is the result of investigations made upon these collections. Fairly complete material was secured of all but two of the living genera, and the investigations include a careful study of the gametophyte and embryo of all the genera investigated, as well as the structure of the adult sporophyte.

No. 58. PEARL, RAYMOND. *Variation and Differentiation in Ceratophyllum.* Octavo, 136 pages, 2 plates, 26 text figures. Published 1907. Price $1.00.

The purpose of this study was to determine, so far as possible, the biological factors concerned in the production of the particular kind of frequency curves of fluctuating variation observed for the plant *Ceratophyllum.* A detailed analysis or "dissection" of the gross frequency curves of variation in terms of the individual variant is made. As a result of this analysis, it is possible to give a clear and definite statement of the factors which immediately determine the degree and kind of fluctuating variation exhibited by the different parts of this plant. The effect of environmental forces on growth and differentiation, and the relationship between intra-individual, intra-racial, and inter-racial variation and correlation are considered.

No. 113. SPALDING, V. M. *Disiribution and Movements of Desert Plants.* Octavo, V+144 pages, 31 plates, 3 figures. Published 1909. Price $2.00.

This paper embodies the results of a study of the factors governing distribution over an area of 4 square miles, including a varied topography, together with col-

lateral data from a much larger area. The author has made an exhaustive experimental analysis of the relations of the plants of the desert to habitat conditions.

The species encountered may be divided into four main groups according to their habitats in the river, in the flood-plain, on the slopes or bajadas, and on the hills or cliffs. Physical properties of the soil, such as soil-moisture and aspect or exposure, are found to be the paramount factors in the determination of local distribution. A large number of the species exhibit a wide range of adjustment and accommodation, particularly with respect to water-supply and temperature. The competitive feature among plants is emphasized as a result of these studies.

No. 4. Conard, H. S. *The Waterlilies. A Monograph of the Genus Nymphæa.* Quarto, xiii+279 pages, 30 plates, including 12 plates colored to life, 82 text figures. Published 1905. Price $6.50.

The paper embodies the results of an attempt to bring together the knowledge of this group in all of its botanical relations, inclusive of the results of hybridizations, and some of the details of culture and uses. The general life-history and physiology of the group, as well as the distribution of the separate species in geologic and present time, receive full consideration. The taxonomic conclusions are based upon the fullest anatomical detail, and the principal forms are well illustrated. An extensive bibliography is appended.

No. 94. Conard, Henry S. *The Structure and Life-history of the Hay-scented Fern.* Octavo, 56 pages, 25 plates. Published 1908. Price $0.50.

Presents a detailed description of the life-history of *Dennstædtia punctilobula*, with results of cultures and detailed anatomical studies.

No. 37. Harper, R. A. *Sexual Reproduction and the Organization of the Nucleus in certain Mildews.* Octavo, 104 pages, 7 plates. Published 1905. Price $0.75.

A presentation of the results of the author's researches upon the organization of the resting nucleus and its relation to the processes of nuclear fusion and division in the mildews. Evidence bearing upon the individuality of chromosomes is presented, alternation of generations in the Ascomycetes is predicted, and it is concluded that the ascocarp originates in a sexual apparatus. The desirability of basing phylogenetic conclusions primarily upon morphological data is made evident.

No. 50. Livingston, Burton E. *The Relation of Desert Plants to Soil Moisture and to Evaporation.* Octavo, 78 pp., 16 figs. Published 1906. Price $0.40.

Embodying the results of quantitative studies of the moisture conditions in desert soil and desert atmosphere, especially in their relation to absorption and transpiration of plants. The conception of *relative transpiration* is developed and its usefulness in such studies demonstrated. Some important data on periodic fluctuations in water-loss and exact measurements of the soil-moisture requirements of several species of desert plants are given.

No. 30. Shull, G. H. *Stages in the Development of Sium cicutæfolium.* (Paper No. 3, Station for Experimental Evolution.) Octavo, 28 pages, 7 plates, 11 text figures. Published 1905. Price $0.25.

No. 112. Shull, G. H. *Bursa bursa-pastoris and Bursa heegeri: Biotypes and Hybrids.* (Paper No. 12, Station for Experimental Evolution.) Octavo, 57 pages, 4 plates, 23 text figures. Published 1909. Price $0.50.

No. 82. Lloyd, Francis E. *The Physiology of Stomata.* Octavo, 142 pages, 40 text figures, 14 plates. Published 1908. Price $1.50.

The investigation described in this paper concerns the questions as to the part played by stomata in the regulation of transpiration and the cause of stomata movement. The physiological rather than the physical view of transpiration is favored by the results. Some new facts concerning guard-cells tend to show that these organs are secretory rather than photosynthetic. Methods of fixing stomatal struc-

tures for examination and a great mass of data bearing on the daily periodicity of transpiration are given. An important contribution on a much-vexed question.

No. 139. Lloyd, Francis E. *Guayule: A Rubber Plant of the Chihuahuan Desert.* Octavo, viii+213 pp., 46 pls., 20 figs. Published 1911. Price $3.50.

This publication embodies the results of an organized attempt to bring under cultivation a hitherto feral desert plant, together with an extensive ecological study of the same under normal and cultural conditions. Careful consideration is given to the questions of rate of growth and reproduction of the guayule in its native habitat, and a large body of pertinent data is given. The various conditions of climate, soil, vegetational environment, and parasitism affecting the plant are presented in this connection. The life history, habit, anatomical and histological structure of the wild and cultivated forms are minutely described and compared, with the purpose of developing exact knowledge concerning the relation between growth and the rate of rubber secretion.

No. 193. MacDougal, D. T., and Collaborators. *The Salton Sea: A Study of the Geography, the Geology, the Floristics, and the Ecology of a Desert Basin.* Quarto, xi+182 pages, 32 plates, 4 figures. Published 1914. Price $5.00.

The geological and biological processes of the surface layers of the earth's crust are profoundly different under subærial exposures to those which prevail under subaqueous conditions. Any region, therefore, which may be subjected to submergence and to weathering, alternately, will offer a changing complex of environic conditions, with accompanying disturbances in the balance and distributional movements of the organisms of the region.

The great Cahuilla Basin, which lies to the westward of the lower or southern part of the main stream of the Colorado River, has been the scene of alternations of the kind in question. The lower part of this basin has been submerged and desiccated many times in the last few hundred years, as attested by the numerous beach or strand formations and layers of travertine on the shores. The making of the lake in 1904, 1905, and 1906, at the time of the organization of the work of the Desert Laboratory, offered opportunities for some studies the results of which are presented in the present paper. The facts to be considered were so diverse in character, and the necessary methods of calibration and estimation so unlike, that the co-operation of a number of workers in various branches of science was enlisted.

A general sketch of the geology and topography of the basin was furnished by the late Prof. W. P. Blake, whose barometric measurements as a member of the Williamson expedition in 1853 first established the fact that the region was an inclosed basin, the lowermost part of which was below sea-level. The history of earlier travel and the general geography of the basin is described by Mr. G. Sykes, geographer of the Desert Laboratory. The analyses of water samples have been carried out under the direction of Prof. R. H. Forbes, at the Agricultural Experiment Station of Arizona, by the aid of Dr. W. H. Ross and Prof. A. E. Vinson. The surface geology, with especial reference to the soil formations, has been the subject of careful examination by Mr. E. E. Free, formerly of the United States Bureau of Soils. Prof. G. J. Peirce, of Stanford University, has contributed the results of studies of organisms living in brackish and saline waters, which are of especial concern with the subject, particularly in the stages of the desiccation of the lake yet to come. Prof. M. A. Brannon, of the University of North Dakota, has carried on a series of cultures by which the specific action of micro-organisms to sulphates, iron, and calcium compounds has been determined and some important facts bearing upon the changes in woody tissue probably initial to the formation of coal have been obtained. Prof. J. C. Jones, of the University of Nevada, has made brief studies of the travertine coatings found on the solid granite near the level of the highest beach line, establishing the participation of biological agencies in their formation. Mr. S. B. Parish, of San Bernardino, has written a description of the plants which form the vegetative setting of the drama of the appearance and disappearance of the lake. Dr. MacDougal has devoted attention chiefly to the revegetation of the areas laid bare by the desiccation of the lake in which

about sixty species have participated. Important contributions have been made to the subjects of dissemination by birds, winds, and by flotation of seeds and seedlings. The re-occupation of sterilized islands has been followed, and the efficiency of various agencies in distribution evaluated.

No. 204. { Livingston, Burton E., and Lon A. Hawkins. *The Water Relation Between Plant and Soil.* Octavo, pages 1-48, 3 text figures.
Pulling, Howard E., and Burton E. Livingston. *The Water Supplying Power of the Soil as Indicated by Osmometers.* Octavo, pages 49-84, 2 text figures. } Published 1915. Price $0.75.

The paper by Livingston and Hawkins gives a discussion of the dynamics of the water relation between plant and soil. The results of experiments with three different species of potted plants are presented, these experiments involving the use of the Livingston auto-irrigator as an indicator of soil-moisture conditions and that of the porous cup atmometer for measuring air-moisture conditions. A method for obtaining a quantitative index of environmental aridity (including both air and soil) is here tentatively set forth.

The paper by Pulling and Livingston presents the results of a study of the resistance offered by soils of various water-contents to the absorption of water by osmometers, these instruments simulating the action of the absorbing surfaces of plant roots. Collodion membranes and cane-sugar solution were employed in the osmometers. The paper includes a discussion of the water-supplying power of soils and of the decrease in this power as water is withdrawn.

No. 206. Johnson, Duncan S., and Harlan H. York. *The Relation of Plants to Tide Levels: A Study of Factors affecting the Distribution of Marine Plants.* Octavo, 162 pages, 24 plates, 5 text figures. Published 1915. Price $2.50.

The vertical and horizontal distributions of some 200 species of plants growing in and about the Inner Harbor at Cold Spring Harbor, Long Island, New York, and the factors determining these have been carefully studied. The tidal changes in water-level for all shore habitats have been accurately measured. The dependent or associated changes in other factors affecting plant distribution have been either measured or estimated and their relative effects analyzed. The distribution of most shore plants in relation to tidal submergence and exposure is much more precisely limited than is indicated by the terms, "between tide marks," "near low-water mark," etc., commonly used to indicate the distribution of littoral organisms. An adequately exact definition is given for the variously used term "littoral." The chief vegetational zones distinguished, with their upper and lower limits, reckoned from mean low-water, are: (1) Plankton of diatoms and Peridineæ. (2) The bottom vegetation (—5. to + 1.5 feet) of algæ, *Zostera* and *Ruppia*. (3) The very sharply marked mid-littoral belt (1.5 to 6.5 feet) including a *Spartina glabra* association on beaches and marshes and a rockweed association on the wharves. (4) The upper littoral belt (6.5 to 8 feet) with quite varied vegetation of algæ, dicotyledons, and monocotyledons. (5) The supra-littoral belt (8 to 12 feet) with indefinite upper limit, and embracing diverse structural types from fresh-water aquatics to xerophytic dune plants.

The environmental factors, whose influences on the distribution of the plants of this harbor are considered, are the following: (1) Substratum, including its physical character, its mobility, and its capacity for drainage and aeration. (2) Water currents, including the dispersal of spores, seeds, and shoot-fragments, the mechanical injury of the plants, the shifting of soil, and the favoring of interchange between the plant and the surrounding water. (3) The submergence and exposure due to tides, which affect the aeration and transpiration, the light supply, the exposure to rain at low-water, and the salinity of the soil water at high levels. (4) The salinity of the soil water and the submerging water, including especially the changes in density during the course of the tide near the numerous fresh-water streams. (5) Temperature of the water, including daily and seasonal changes.

The important general conclusion is reached, as a result of observations here and at other points on the Atlantic Coast, that the vertical range of a plant common to two localities with different ranges of tide will be found exactly proportional in each place to the local range of tide.

No. 209. Richards, Herbert M. *Acidity and Gas Interchange in Cacti.* Octavo, 107 pages, 6 figs. Published 1915. Price $1.00.

This paper presents the results of a somewhat detailed study of the behavior of the acidity and gas interchange of *Opuntia versicolor,* together with some data from other cacti. The section on acidity determinations embodies a consideration of the periodicity of acid formation and disappearance, with experimental data and discussion of the various external factors which influence the acid content of the tissues. Following this is a chapter on the respiration of cacti as determined by the Pettenkofer method in which especial attention is called to the lag in response of the rate of carbon-dioxide evolution with changing temperatures. The third part of the paper treats of gas interchange in connection with the determination of what is commonly termed the respiratory quotient. The effect of light, darkness, increased or diminished oxygen supply, rising and falling temperatures, wounding, etc., are described. The paper closes with a short consideration of the question of respiration in general, especially in connection with the peculiar phenomena presented by the cacti.

No. 218. Stout, A. B. *The Establishment of Varieties in Coleus by the Selection of Somatic Variations.* Octavo, 80 pages, 4 plates, 29 figs. Published 1915. Price $2.00.

This study pertains to the frequency, the permanence, and the nature of somatic variations involving leaf-shape and variegation in *Coleus,* and to an analysis of such phenomena with reference to the expression and the inheritance of characters. A single variety of *Coleus* propagated vegetatively in pedigreed cultures through six generations (833 plants) developed two types of changes: (1) fluctuations, and (2) mutations, giving a total of 16 distinct color patterns and a type of plant with periodically laciniate leaves. Selection was effective in maintaining 15 color patterns remarkably constant in vegetative propagation; these exhibited, however, further variations.

The phenomena associated with the appearance and the subsequent behavior of the different variations are quite similar to variation and mutation in seed progenies and to alternative inheritance in hybrid progenies. The results show that in *Coleus* asexual and sexual reproduction are not fundamentally different in respect to the extent and range of variation. Furthermore, the phenomena illustrate, in the development of green, yellow, and red coloration, the behavior of metidentical qualities and show equally well that the distribution of colors in patterns is due to inter-cellular and inter-tissue relations and is without doubt due to physical and chemical processes quite analogous to the Liesegang precipitation phenomena.

No. 194. Shreve, Edith B. *The Daily March of Transpiration in a Desert Perennial.* Octavo, 64 pages, 1 plate, 27 figures. Published 1914. Price $0.75.

A study of *Parkinsonia microphylla* was undertaken with a desire to determine some of the means by which a non-succulent desert perennial passes the drought periods which occur twice each year in the climate in which it flourishes. The results found can be divided into two classes: the external means and the internal. The external means involves the lessening of the transpiring surface caused by the dying and dropping of leaves, twigs, and sometimes whole branches without injury to the life of the plant. The internal means involves the lessening of the water loss per unit area during the forenoon, when the evaporating power of the air is increasing. This decrease is accompanied by a lowering of water content of leaves and twigs, by a partial closure of stomatal openings, and by a rise in leaf temperature. The transpiration rate was greatly decreased when the soil moisture became low.

No. 199. Shreve, Forrest. *A Montane Rain-forest: A Contribution to the Physiological Plant Geography of Jamaica.* Octavo, 110 pages, 29 plates, 18 figs. Published 1914. Price $1.50.

The Blue Mountains of Jamaica are covered with a virgin rain-forest, in which some of the habitats are among the most moist of the western hemisphere. A description of the ecological and floristic characteristics of the rain-forest above 4,500 feet elevation is given, and the various habitats of the region are described. The climatic factors of environment are tabulated for the Blue Mountain region as a whole, and particular attention is given to the measurement of the differences of climatic conditions which underlie the dissimilarity of the conditions on the floor of the rain-forest and in its canopy. The periodicity of growth and flowering in the commonest trees and shrubs is described, and detailed measurements of the rate of growth are given. The influence of the low and constant temperatures, the high percentages of cloudiness and fog, and of the high and sustained humidities of the rain-forest are such as to retard both photosynthetic and transpirational activity, an effect which is registered in the slow rates of growth and is so pronounced as to make the montane rain-forest a very unfavorable environment for plants as contrasted with tropical lowlands and the moist temperate regions. Studies of the transpiration of plants from unlike habitats within the rain-forest indicate that dissimilarities of transpiration behavior with respect to moisture conditions underlie the localization of species in the several habitats.

No. 217. Shreve, Forrest. *The Vegetation of a Desert Mountain Range as Conditioned by Climatic Factors.* Octavo, 112 pages, 37 plates, 18 figs. Published 1915. Price $2.00.

The principal aim of this work has been to correlate the climatic gradients of a relatively isolated desert mountain range with the vertical differences of vegetation which it exhibits. The Santa Catalina Mountains are characterized by desert on their lower slopes, by encinal (evergreen oak forest) at their middle elevations, by pine forests above 7,000 feet, and by fir forest on the highest summits. These types of vegetation have been fully described and illustrated. Nearly all the species of plants are distributed so definitely with relation to altitude and habitat as to indicate that they are controlled in their movements and establishment by the operation of physical factors. The major differentiation of vegetation on the mountain is controlled by the factors which are in turn due to differences of altitude. The major influences of slope exposure and other topographic features cause local departures from the normal altitudinal gradient of vegetation, but these departures are merely such as to bring a given type of vegetation to an altitude higher or lower than that in which it is commonly found. Rainfall, soil moisture, evaporation, and temperature have been studied at a series of stations reaching from 3,000 to 9,000 feet, at 1,000-foot intervals. The influence of slope exposure on the conditions of soil moisture and evaporation and the influence of topography in modifying the theoretical conditions of temperature have been particularly emphasized. It has been necessary to study the vertical gradient of temperature with special reference to the operation of cold-air drainage, which is very pronounced throughout the lightly forested or unforested portions of the mountain. Comparisons have been made between the climatic gradients of the Santa Catalinas and gradients derived from the Weather Bureau stations of southern Arizona, situated at different elevations in the valleys of the adjacent region. These comparisons are particularly significant with respect to the rainfall conditions, showing that the isolated mountains have a greater rainfall at 4,000 and 5,000 feet than localities in the valleys at the same elevations. The coldest temperatures of winter at 8,000 and 9,000 feet are much milder on an isolated mountain, surrounded by desert, than they are at the same elevation on extensive plateaus.

No. 242. Clements, Frederic E. *Plant Succession: An Analysis of the Development of Vegetation.* Octavo. In press.

This treatise is an endeavor to give a complete account of the development of vegetation and to lay down the basic procedure upon which future research must rest. The analysis falls into three general divisions. One of these is historical, and brings together practically all the results so far obtained in the field. The development of successional ideas is traced by an analysis of major contributions from the seventeenth century to the present. For North America abstracts are given of all the works upon succession, and these are arranged under the various climaxes and seres. The studies of European succession are summarized by regions, while a special section is devoted to investigations of peat horizons. A consistent attempt is made to take into account all existing results and interpretations. A chapter is devoted to the quadrat and instrument methods which are regarded as indispensable to adequate research.

The treatment of present-day succession falls under several heads, namely, concept and causes of succession, initial causes, ecesic causes, reactions, stabilization and climax, structure and units of vegetation, direction of development and classification of seres. An account is given of the topographic, climatic, and biotic forces which initiate succession, and of the processes, aggregation, migration, ecesis, competition, and reaction, which carry it on. The relation of stabilization to climax is discussed, and subclimax, preclimax, and postclimax are distinguished. Vegetation structures are interpreted as the outcome of development, and hence as universal evidences of it. The concept of the formation is made as objective as possible by basing it wholly upon development. As a result, each climax becomes a formation, in which it is necessary to recognize certain climax units, association, consociation, and society, and developmental ones, associes, consocies, and socies.

In analyzing the various views upon regression and retrogression, the conclusion is reached that development is always progressive. Regression is only the halting of succession in consequence of partial or complete denudation, followed by the resumption of the normal progressive movement. The various bases for the classification of seres or unit successions are examined, and a system is proposed in which the climax is adopted as the primary criterion. Within each climax, seres are distinguished as priseres and subseres with respect to the course of development, and as hydroseres and xeroseres with reference to the initial water-content of the bare area.

The assumption is made that succession took place during the geological past essentially as at present, and the field of paleo-ecology is organized upon this basis. In the discussion of past climates and climaxes, an account is given of vegetation eras, the plant record, deformation and gradation, past climates, with geologic, botanic and zooic evidences of them, climatic changes, climatic cycles, and the correlation of cycles and succession. On the basis of climax vegetations, four great eras are recognized, viz., Eophytic, Paleophytic, Mesophytic, and Cenophytic. Successionally, each of these is characterized by an eosere, e.g., the Ceneosere, while collectively, the four eoseres constitute the geosere, the total succession of the geological past. The various kinds of cycles are dealt with at length, and a tentative chart of them is constructed. The general principles of the phylogeny and ontogeny of vegetation are formulated, and a somewhat detailed sketch is given of succession during the Cenophytic and Mesophytic eras, and a general account of the Paleophytic era.

For other works relating to Botany, see Nos. 24 and 30 on page 85; 81 on page 86; 112 on page 87; and 192 on page 109.

BACTERIA IN RELATION TO PLANT DISEASES.

No. 27. SMITH, ERWIN F. *Bacteria in Relation to Plant Diseases.* Vol. I, quarto, XII+285 pages, 31 plates, 146 figures. Published 1905. Price $4.00.

An outline of methods of investigation of bacterial diseases of plants in the laboratory, field, and greenhouse is given, with figures and descriptions of various pieces of apparatus and of various diseases; among the latter: Pear and apple blight; brown rot of potato, tomato, and tobacco; walnut blight; wilt of cucumber and melon; leaf-stripe of broom-corn; black-spot of the plum; larkspur disease; angular leaf-spot of cotton; soft rot of cucumber; black-rot of cabbage and turnip; Stewart's disease of sweet corn; iris rhizome rot; olive tubercle. A bibliography of general bacteriology exclusive of plant diseases is included and is arranged under 57 heads; it gives brief abstracts of some of the papers, and the chronological arrangement shows at a glance the development of the subject.

———. Vol. II. *History, General Considerations, Vascular Diseases.* Quarto, VIII+368 pages, 22 plates, 149 figures. Published 1911. Price $5.00.

Volume II, although intended primarily for plant pathologists, contains much of interest to the general reader. To the student it gives, in easily understood phraseology, authentic descriptions, methods, and definitions. It is the result of personal research of the author and his assistants through a long series of years.

The first 200 pages are devoted to a general discussion of the problems of plant bacteriology, such as the supposed normal occurrence of bacteria in plants; bacteria on the surface of plants; entrance of bacteria into plants; the question of parasitism; carriers of infection; specific diseases; the experimental production of parasites; manner of infection; reaction of host to parasite; a discussion of the newest ideas on plant tumors, *i. e.,* relating them to animal tumors (with some striking illustrations); tissues attacked; solvent action of bacteria; enzymes; resistance to bacterial attack; immunity; symbiosis; cross inoculations with plant and animal parasites; plants as carriers of disease; plant hygiene. Several pages are devoted to germicides and insecticides with abstracts of the more important papers published on these subjects. Chronological bibliographies are also appended. Under *symbiosis* there is a full account of the root-tubercles of legumes.

The last 150 pages are devoted to three vascular diseases: wilt of cucurbits, black-rot of cruciferous plants, and the yellow disease of hyacinths. On the first of these diseases little has been published and the author's observations and experiments, covering a period of 19 years, are reported in full. Each disease is discussed under the heads: Definition, host plants, geographical distribution, signs, etiology, morbid anatomy, the parasite, treatment, pecuniary losses, history, literature.

———. Vol. III. *Vascular Diseases.* Quarto, VIII+309 pages, 47 plates (4 colored), 155 text figures. Published 1914. Price $5.00.

This volume deals about equally with diseases of monocotyledons and dicotyledons, principally with diseases of sugar-cane and maize and with those of potato, tomato, and tobacco. There is a chapter on a very curious and interesting grass disease, namely that of *Dactylis;* also chapters on some other little-known European and tropical diseases, including those of the banana. In connection with Cobb's disease of sugar-cane, there is a discussion of the East Indian Sereh and of the South American disease known as Polvillo. A full account is given of Stewart's disease of sweet corn and all the evidence going to show that it is disseminated on the seed. The morphology and cultural characters of *Bacterium solanacearum* are given in full. The destructive tomato disease, due to *Aplanobacter michiganense,* is also illustrated and distinguished from that due to *Bacterium solanacearum.* Growers of tobacco will find a separate chapter on the bacterial wilts of tobacco. Original illustrations have been used, many representing all phases of the disease and the morphology and cultural characters of the parasite. As in volume II the results given depend in most cases primarily on the author's own researches, but the literature on each disease is carefully reviewed, and that difficult to obtain is abstracted in full, when it is of special interest, as in case of the copious Dutch East Indian literature on the tobacco wilt. The chronological bibliographies showing the historical development of each subject are continued.

CLIMATOLOGY AND GEOGRAPHY.

No. 192. HUNTINGTON, ELLSWORTH, with contributions by CHARLES SCHUCHERT, A. E. DOUGLASS, and CHARLES J. KULLMER. *The Climatic Factor, as illustrated in Arid America.* Quarto, 341 pages, 12 plates, 2 maps, 90 figures. Published 1914. Price $5.50.

This study of changes of climate is a continuation of the work described in the author's papers in Nos. 26 and 73. It deals mainly with the relation of climate to geological, botanical, and archeological phenomena, but contains also a considerable amount of geographical description. The book begins with a discussion of the present climate of Arizona and New Mexico, and its effect upon the earth's surface and upon vegetation. Because of the aridity and scanty vegetation, deposits of alluvium are abundant and many are terraced. A consideration of whether these terraces are of climatic or tectonic origin leads to the conclusion that they are climatic, and that they indicate climatic pulsations during the period of human occupation. Numerous ruins, here and in Mexico, Yucatan, and Guatemala, point to the same conclusion and suggest the existence of at least three moist periods separated by times of aridity.

An independent investigation of the same problem, based on the method of Prof. A. E. Douglass, shows that the amount of rainfall may be determined from the thickness of rings of growth in trees. From measurements of 450 Sequoias in California a curve has been plotted showing the approximate pulsations of rainfall in California for 3,000 years. Comparison with meteorological records suggests that the pulsations consist of an alternate weakening and strengthening of atmospheric circulation, whereby climatic zones are moved first poleward, then equatorward.

This conclusion leads to an attempt to determine the cause of changes of climate, including not only recent changes, but those of geological times, which are discussed by Professor Schuchert, who lays special emphasis upon the importance of broad crustal deformation. Such deformation, however, can scarcely account for glacial and inter-glacial epochs, and much less for the pulsations indicated by the California trees. Only the solar hypothesis seems adequate. This conclusion is tested by investigating the possibility of a connection between variations in sun spots and changes in the growth of trees. Such a connection seems to exist, and various phenomena suggest that apparent discrepancies are in reality results that would naturally be expected.

Chapters 2, 4, 5, 6, and 10 deal with the geological problem of the effect of aridity upon surface forms and upon subaerial deposits. The problem of the tectonic versus climatic origin of alluvial terraces in dry mountain regions is treated at length. Chapters 19, 20, and 21 discuss theories of climatic changes, special emphasis being given to the solar hypothesis as the cause of changes of the magnitude of glacial epochs or less, and to crustal deformation as the cause of greater changes, such as glacial periods.

Inasmuch as botanical evidence is largely used in elucidating the climate of the past, Chapter 2 describes the arboreal desert of the southwestern United States. Chapters 11 to 14 discuss the relation of the thickness of rings of growth to climatic conditions, not merely in the case of the Sequoia of California, but among trees from all parts of the country. The evidence presented in Chapters 15, 16, and 17 suggests that in equatorial regions plant formations may be displaced by climatic changes with a degree of rapidity which must cause the process of natural selection to act with greater speed than is commonly supposed.

The climate of the past stands in vital relation not only to geology and botany, but to men. Hence it is necessary to consider fully the ruins of the Southwest and the conditions under which the people lived. This is done in Chapters 6 to 10. The ruins and civilization of the Mayas in Yucatan and Guatemala are also important lines of evidence, and in Chapters 15 to 18 the theory is advanced that when the Mayas were in their prime the lowlands of this region were decidedly drier than now.

No. 16. JENNINGS, HERBERT S. *Contributions to the Study of the Behavior of Lower Organisms.* Octavo, 256 pages, 81 text figures. Published 1904. Price $1.00.

This consists of a series of investigations of the behavior and reactions of a number of lower organisms, chiefly unicellular forms; together with a discussion of the theories dealing with these matters. Detailed experimental results are given for the reactions of infusoria to heat and cold, and to light; for the reactions of certain Rotifera to various stimuli; and a full account is presented of the movements and reactions of Amœba. The general chapters deal with the Theory of Tropisms, with Physiological States as determining factors in Behavior, and with the "Method of Trial and Error."

No. 20. DUERDEN, J. E. *The Coral Siderastrea radians.* Quarto, v+130 pages, 11 plates, 13 text figures. Published 1904. Price $1.00.

This book sets forth the results of studies in the early stages of the development of the coral *Siderastrea radians,* including the development of the tentacles and septa as far as the third cycle and that of the mesenteries to the completion of the second cycle. An account is first given of the external characters and internal anatomy of the adult colony, and afterward of the development of the young polyp from the free-swimming larva. The manner of appearance and the relationship of the tentacles, mesenteries, and septa are considered at some length, their establishment being the principal object of the investigation.

No. 32. DEAN, BASHFORD. *Chimæroid Fishes and Their Development.* Quarto, 194 pages, 11 plates, 144 text figures. Published 1906. Price $4.00.

A general account of a group of fishes which by some investigators has been described as the most primitive of all vertebrates. The present memoir considers this claim especially from the evidence contributed by the fossil members of the group and by the embryonic history of a living species, the Californian *Chimæra colliei.* It is shown that chimæroids are widely modified rather than primitive, and in all probability are descendants of the early type of the Port Jackson shark (*Cestracion*). The work is illustrated by beautifully executed text figures and colored plates, and presents a complete list of the literature of the subject.

No. 47. MAYER, ALFRED G. *Rhythmical Pulsation in Scyphomedusæ.* Octavo, 62 pages, 2 plates, 36 text figures. Published 1906. Price $0.50.

This paper describes the effects of the cations of sea-water, sodium, magnesium, calcium, and potassium upon pulsation in jellyfishes, and the hearts of salpæ and of turtles. It is shown that if any strip of tissue capable of pulsation be cut into the shape of a closed circuit, and then set into pulsation, it will maintain itself in movement for an indefinite period of time. This paper should be read in connection with the author's second paper on the same subject in Publication No. 102.

No. 109. MAYER, ALFRED G. *The Medusæ of the World.* Quarto. In three volumes. Published 1911. Price $6.00 per volume.

I. The Hydromedusæ, pp. 1-230+xv, plates 1-29, text figures 1-119.
II. The Hydromedusæ (continued), pp. 231-498+xv, plates 30-55; text figures 120-327.
III. The Scyphomedusæ, pp. iii+499-735, plates 56-76, text figures 328-428.

This work is the only general treatise upon medusæ which has appeared since Haeckel published Das System der Medusen in 1879-80.

The first two volumes treat of the Hydromedusæ and the third is devoted to the Scyphomedusæ. The colored plates are all drawn from life, and, with few exceptions, are confined to the representation of American Medusæ. The text figures, on the other hand, chiefly represent foreign forms, and are mostly reproductions from the drawings of other authors. The work presents not only a system of classification for the medusæ, but also devotes much attention to the philogeny, embryology, physiology, regeneration, habits, and œcology of the medusæ.

No. 162. MAYER, ALFRED G. *Ctenophores of Atlantic Coast of North America.* Octavo, 58 pages, 17 plates, 12 figures. Published 1912. Price $2.75.

This paper gives a systematic description, accompanied by drawings from life, of all ctenophores known to occur off the Atlantic coast of North America from the Arctic Ocean to the tropics. The embryology, physiology, habits, and anatomy of the American Atlantic ctenophores are also discussed, and reviews of all papers bearing upon these subjects are presented.

No. 102. Papers from the Tortugas Laboratory of the Carnegie Institution of Washington. Vol. I. Octavo, v+191 pages, 41 text figures, 43 plates. Published 1908. Price $2.00.

This book contains the following papers, *not sold separately:*

JORDAN, H. E.—The Germinal Spot in Echinoderm Eggs. 12 pages.
JORDAN, H. E.—The Spermatogenesis of *Aplopus mayeri*. 24 pages, 5 plates.
JORDAN, H. E.—The Relation of the Nucleolus to the Chromosomes in the Primary Oocyte of *Asterias forbesii*. 36 pages, 7 plates.
BROOKS, W. K.—Pelagic Tunicata of the Gulf Stream: Part II, *Salpa floridana*. Part III, The Subgenus Cyclosalpa. Part IV, On *Oikopleura tortugensis*, a new Appendicularian from the Dry Tortugas, with Notes on its Embryology. 16 pp., 8 pl.
BROOKS, W. K., and B. MCGLONE.—Origin of the Lung of Ampullaria. 8 pp., 7 pl.
MAYER, A. G.—The Annual Breeding-swarm of the Atlantic Palolo. 8 pp., 1 pl.
MAYER, A. G.—Rhythmical Pulsation in Scyphomedusæ. 18 pages.
PERKINS, H. F.—Notes on Medusæ of the Western Atlantic. 84 pages, 4 plates.
LINTON, EDWIN.—Helminth Fauna of the Dry Tortugas. I, Cestodes. 34 pages, 11 plates.
EDMONDSON, C. H.—A Variety of *Anisonema vitrea*. 1 page.

Jordan's paper upon Echinoderm eggs casts doubt upon the theory of the individuality of the chromosomes in inheritance. His paper upon *Aplopus* shows that one half of the spermatozoa contain 18 and the other half 17 chromosomes, the accessory chromosome apparently being a sex determinant.

Brooks corrects certain errors in previous descriptions of *Salpæ*, and also describes a new Appendicularian, with an account of its house and its embryology.

Brooks and McGlone find that there is no reason to believe that there is any ancestral connection or relationship between the lung of the prosobranchiate gastropod *Ampullaria* and that of the pulmonates, although the embryonic history of the lung of *Ampullaria* shows that the origin of the lung of the pulmonates through the modification of a gill is not impossible.

Mayer finds that the tidal rise and fall has nothing to do with causing the remarkable breeding swarm of the Atlantic palolo (*Eunice fucata*), which swarms in great numbers upon the surface of the sea early in the morning of the day of the last quarter of the July moon.

Mayer also finds that the pulsation of Scyphomedusæ is caused by the stimulus due to the maintenance of a slight excess of ionic sodium at the nerve centers, also that sea water is a balanced fluid for pulsation, containing both stimulants and inhibitors, which exactly offset one another.

Perkins describes a new species of *Cladonema* and gives an account of its hydroid, and an *Aglaura* is also described as new. The habits and embryology of *Cassiopea* are discussed.

Linton describes a considerable number of fish parasites from the Tortugas region, and establishes new genera and species.

No. 103. Papers from the Tortugas Laboratory of the Carnegie Institution of Washington. Vol. II. Octavo, v+325 pages, 62 text figures, 41 plates. Published 1908. Price $3.00.

This book contains the following papers, *not sold separately:*

COWLES, R. P.—Habits, Reactions, and Associations in *Ocypoda arenaria*. 41 pp., 4 pl.
STOCKARD, C. R.—Habits, Reactions, and Mating Instincts of the Walking-stick. 17 pp., 3 pl.
STOCKARD, C. R.—Studies of Tissue Growth: 1. An Experimental Study of the Rate of Regeneration in *Cassiopea xamachana*. 42 pages.
ZELENY, CHARLES.—Some Internal Factors Concerned with the Regeneration of the Chelæ of the Gulf-weed Crab. 36 pages.
CHAPMAN, F. M.—A Contribution to the Life-histories of the Booby and Man-o'-war Bird. 13 pages, 6 plates.
CONKLIN, E. G.—The Habits and Early Development of *Linerges mercurius*. 18 pp., 8 pl.
CONKLIN, E. G.—Two Peculiar Actinian Larvæ from Tortugas, Florida. 16 pp., 4 pl.
WATSON, J. B.—The Behavior of Noddy and Sooty Terns. 69 pp., 11 pl.
REIGHARD, JACOB.—An Experimental Field-study of Warning Coloration in Coral-reef Fishes. 69 pp., 5 pl.

Dr. Cowles shows that the sand crab *Ocypoda arenaria* has memory and can profit by experience, and also that it can not detect color, although it readily perceives a moving object. The color-pattern of the crab changes under different conditions of light and heat.

Stockard shows that the habits of the walking-stick insect *Aplopus* accord with and enhance the value of its remarkable protective coloration.

In his second paper, Stockard finds that regenerating tissue grows, if necessary, at the expense of the body itself, and if starved the old body actually decreases in size to provide nutriment for the rapidly proliferating cells of the regenerating tissue. He shows that in its remarkable ability to absorb nutriment regenerating tissue resembles cancer and other malignant tumors. He finds that $CaCl_2$ and NaCl tend to retard regeneration, as do also strong solutions of KCl, but weak solutions of KCl accelerate the process.

Zeleny studied the regeneration of the chelæ of the gulf-weed crab (*Portunus sayi*) and found that there is no change in the power of regeneration as a result of successive removal in the chelæ, also that there is no appreciable change in the left chela as a result of the removal and regeneration of the right chela. He also studied regeneration in the medusa *Cassiopea* and discovered that the rate of regeneration is independent of the functional activity or inactivity of the medusa.

Chapman discovered that the booby (*Sula fiber*), which nests upon Cay Verde, Bahamas, between February and April, lays two eggs, but rears only one young bird. His observations and collections upon Cay Verde have led to the construction of a group in the American Museum of Natural History illustrating the nesting habits of the frigate-bird and the booby.

Prof. Edwin G. Conklin finds that the egg of the Scyphomedusa *Linerges* consists of a peripheral layer of clear protoplasm, an intermediate shell of densely packed yolk-spherules, and a central sphere of dissolved yolk. The peripheral layer of the egg forms the peripheral layer of the gastrula and blastula and gives rise to the cilia of the ectoderm. The middle layer constitutes the principal part of all of the cells of the body, while the central yolk serves for nourishment. Thus animals so low as the medusæ show the beginning of that differentiation of organ-forming substances in the egg which Professor Conklin discovered was so characteristic of the eggs of higher forms.

In another paper Conklin treats of the anatomy and habits of two peculiar, free-swimming Actinian larvæ.

Prof. John B. Watson conducted very elaborate analytical studies of the nesting habits of sea gulls. He caused birds to be taken from Bird Key to Havana, 80 miles, to Key West, 66 miles, and to Cape Hatteras, 850 miles from Bird Key. Liberated at these places they soon returned to their nests on Bird Key.

Professor Reighard gives an account of his experiments, performed at Tortugas, which are by far the most convincing that have ever been carried out upon the subject of warning coloration, being performed in surroundings natural to the animals themselves. He concludes that the conspicuous coloration of coral-reef fishes is the result of race tendency unchecked by selection. Warning coloration may, however, be artificially established, but appears not to exist in nature, at least in so far as the Tortugas reef-fishes are concerned.

No. 132. Papers from the Tortugas Laboratory of the Carnegie Institution of Washington. Vol. III. Octavo, 152 pages, 38 text figures, 17 plates. Published 1911. Price $3.00.

This book contains the following papers, *not sold separately:*

Mayer, Alfred G.—The Converse Relation between Ciliary and Neuro-muscular Movements. 25 pages, 8 text figures.

Harvey, E. Newton.—Effect of Different Temperatures on the Medusa *Cassiopea*, with Special Reference to the Rate of Conduction of the Nerve Impulse. 13 pages, 5 text figures.

Stockard, Charles R.—The Influence of Regenerating Tissue on the Animal Body. 8 pages, 3 text figures.

Hargitt, Charles W.—*Cradactis variabilis:* An Apparently New Tortugan Actinian. 5 pages, 1 plate.

McClendon, J. F.—On Adaptations in Structure and Habits of Some Marine Animals of Tortugas, Florida. 8 pages, 2 plates, 1 text figure.

MAST, S. O.—Behavior of the Loggerhead Turtle in Depositing its Eggs. 5 pages.
HOOKER, DAVENPORT.—Certain Reactions to Color in the Young Loggerhead Turtle. 8 pages, 2 plates, 1 text figure.
STROMSTEN, FRANK A.—A Contribution to the Anatomy and Development of the Posterior Lymph Hearts of the Turtle. 11 pages, 2 plates, 5 text figures.
HARTMEYER, R.—*Polycitor* (*Eudistoma*) *mayeri* nov. sp., from the Tortugas. 5 pages, 1 plate.
COWLES, R. P.—Reaction to Light and other points in the Behavior of the Starfish. 16 pages, 6 figures.
TENNENT, D. H., and V. H. KEILLER.—The Anatomy of *Pentaceros reticulatus*. 6 pages, 3 plates, 2 figures.
TENNENT, D. H.—Echinoderm Hybridization. 36 pages, 6 plates, 7 text figures.

Mayer states that, whatever effect the cations sodium, magnesium, potassium, calcium, ammonium, hydrogen, or CO_3 may have upon neuro-muscular movements, their effects upon the movements of cilia are the exact opposite.

Harvey shows that it is probable that in the Scyphomedusa *Cassiopea* the origination of stimuli in the nerve-organs is dependent upon the progressing of some chemical reaction. He finds also that nerve conduction exhibits a falling off in rate with rise of temperature similar to that observed in enzyme action, and he is led to conclude that the propagation of the nerve impulse is not only dependent upon the velocity of a chemical reaction, but that the reaction is still further accelerated by the presence of an enzyme.

Stockard shows that regenerating tissue possesses an excessive capacity for the absorption of nutriment, which it obtains at the expense of the old body-tissues, causing them to decrease in size as does the growth of a rapidly growing tumor. The rate of regeneration is independent of the extent of injury and either remains constant or decreases with greater injury.

Hargitt describes an actinian *Cradactis variabilis*, which is believed to be new to science and which lives in the crevices of the coral reefs.

McClendon shows that a Pontoniid, *Typton tortugæ*, displays a convergence in structure and habits with *Alpheus* and lives with the latter in the cavities of loggerhead sponges. Both forms are thigmotactic and prefer to remain in glass tubes rather than in an open aquarium. He also describes the habits of the sea-anemone *Cradactis variabilis* Hargitt, which can detach its base from the rocks and move about upon the tips of its tentacles.

Mast gives a detailed description of the behavior of the loggerhead turtle in scooping out the sand and depositing its eggs in the nest thus formed.

Hooker finds that the newly hatched loggerhead turtles are strongly attracted by the blue of the sea or of the sky above the sea, and thus under normal conditions move away from the green bushes and go straight toward the ocean.

Stromsten shows that in the embryo of the loggerhead turtle the mesenchymal spaces capture certain capillaries and convert them into the anlagen of the posterior lymph hearts.

Hartmeyer describes a new species of ascidian, *Polycitor (Eudistoma) mayeri*, from the Tortugas.

Cowles finds that the starfish *Echinaster crassispina* usually moves from dimly to brightly lighted regions independent of the direction or color of the light rays. At temperatures lower than 17.8° or higher than 34.4° C. it ceases to move. It perceives light not only by means of the eye spots at the tips of the arms, but a large part of the aboral surface is sensitive to light; and in *Pentaceros* the tube-feet and gills react definitely to changes in intensity of light.

Tennent and Keiller give a description of the anatomy of the giant starfish *Pentaceros reticulatus* and find that there are two contractile intestinal cæca in each arm.

Tennent reviews the whole history of the study of Echinoderm hybridization, describes many new experiments of his own, and gives a detailed account of the results of his research wherein in reciprocal crosses between *Hipponoë* and *Toxopneustes* he finds that in ordinary or in alkaline sea-water *Hipponoë* is dominant, while in sea-water to which a slight amount of acetic or hydrochloric acid has been added *Toxopneustes* becomes dominant.

No. 133. Papers from the Tortugas Laboratory of the Carnegie Institution of Washington. Vol. IV. Octavo, III+185 pages, 43 plates, 17 text figures. Published 1910. Price $4.00.

This book contains the following papers, *not sold separately:*

PRATT, HENRY S.—*Monocotyle floridana*, a new Monogenetic Trematode. 9 pp., 11 figs.
LINTON, EDWIN.—Helminth Fauna of the Dry Tortugas. II. Trematodes. 87 pages, 28 plates.
VAUGHAN, THOMAS WAYLAND.—A Contribution to the Geologic History of the Floridian Plateau. 86 pages, 15 plates, 6 text figures.

Professor Pratt describes the only Trematode known to have a complete intestinal tract, the two intestinal trunks uniting to form a posterior cæcum which may open to the exterior by a terminal pore on the dorsal side of the animal.

Professor Linton describes 46 new species of parasitic Trematodes from the fishes and turtles of the Tortugas region.

Dr. T. Wayland Vaughan traces the geologic history of the Floridian Plateau from Oligocene to Recent time; records the results of his exploration of the Florida Keys in the yacht *Physalia*, and presents a report on material from the sea-bottom; he traces the several elevations and depressions, and calls special attention to the important rôle currents have played in shaping the contours of the banks of southern Florida.

No. 182. Papers from the Tortugas Laboratory of the Carnegie Institution of Washington. Vol. V. Octavo, III+222 pages, 7 plates, 3 maps, 68 figures. Published 1914. Price $2.00.

This book contains the following papers, *not sold separately:*

MAYER, A. G.—In Memoriam, George Harold Drew. 6 pages, 1 plate.
DREW, G. H.—On the Precipitation of Calcium Carbonate in the Sea by Marine Bacteria, and on the Action of Denitrifying Bacteria in Tropical and Temperate Seas. 39 pages, 2 maps, 4 figs.
VAUGHAN, T. W.—Preliminary Remarks on the Geology of the Bahamas, with Special Reference to the Origin of the Bahaman and Floridian Oolites. 8 pages.
VAUGHAN, T. W.—Building of the Marquesas and Tortugas Atolls and a Sketch of the Geologic History of the Florida Reef Tract. 13 pages.
DOLE, R. B.—Some Chemical Characteristics of Sea-Water at Tortugas, Florida. 9 pages, 1 map.
CARY, L. R.—Observations upon the Growth-Rate and Œcology of Gorgonians. 12 pages, 2 plates.
CLARK, H. L.—Growth-Changes in Brittle-Stars. 36 pages, 3 plates.
TENNENT, D. H.—The Early Influence of the Spermatozoan upon the Characters of Echinoid Larvæ. 12 pages, 11 figs.
JACKSON, ROBERT T.—Studies of Jamaica Echini. 24 pages, 21 figs.
JORDAN, H. E.—The Spermatogenesis of the Mongoose; and a Further Comparative Study of Mammalian Spermatogenesis, with Special Reference to Sex Chromosomes. 20 pages, 1 plate, 9 figs.
OSBURN, R. C.—The Bryozoa of the Tortugas Islands, Florida. 42 pages, 23 figs.

The posthumous paper of George Harold Drew states that the fine unorganized chalky mud of the Bahama Banks and Florida Keys is a precipitate due to bacterial action on the calcium salts present in solution in the sea-water. Also bacterial denitrification of the sea-water is far more complete in tropical than in temperate parts of the Atlantic and this explains the relative scarcity of plankton and plant-growth in tropical seas, as was first determined by Brandt.

Dr. T. Wayland Vaughan shows that the unorganized chalky mud which is precipitated by bacterial action may eventually become converted through accretion into oolite in the manner explained by Linck. Dr. Vaughan also traces the history of the several submergences and uplifts which have resulted in the formation of the present Bahama and Florida reef regions. He states also that the lagoons and sounds of this region are due to constructional geologic processes and not to marine solution of limestone. The Barrier Reef of Florida, like that of Australia, is growing along the seaward edge of a submerged platform which was submerged and formed before the reefs began to grow upon it. Thus the reefs are a mere incident and not a cause of the platform.

Mr. R. B. Dole concludes that the water of the Tortugas lagoon and of Biscayne Bay, Florida, contains no free carbon dioxide, and can not dissolve limestone by virtue of its content of carbonic acid. This accords with Vaughan's conclusion that the lagoons and sounds of southern Florida are filling up and are not being dissolved out by the sea-water.

Dr. L. R. Cary has determined the growth rate of various Gorgonians and decides that, at Tortugas, hurricanes are the most serious factor interfering with the growth of these animals. The average rate of growth in young specimens is about 50 mm. in height per annum, but it ranges greatly in different individuals and under different environmental conditions.

Dr. Hubert Lyman Clark points out the importance of the study of the development, growth stages, and paleontological history of the brittle stars in order to determine a natural system for their classification. He then proceeds to present the results of his study of the growth changes in three species of brittle stars belonging to the genera *Ophiactis*, *Amphipholis*, and *Ophiothrix*.

Professor David H. Tennent shows that in hybrid larvæ between the two echini, the male of *Toxopneustes* and female of *Cidaris*, the sperm shows its influence over the development from the earliest stages of gastrulation and mesenchyme formation.

Professor Robert Tracy Jackson describes the results from his study of the ocular plates of 2,878 specimens of Echini from Montego Bay, Jamaica; the research being an extension of his notable work, the "Phylogeny of the Echini."

Professor H. E. Jordan shows that there are no accessory chromosomes in the male Mongoose, cat, squirrel, pig, and rabbit, but these are apparently found in the white mouse, sheep, horse, mule, bull, and dog. The accessory chromosome may act as a deterrent to the development of maleness.

Dr. Raymond C. Osburn describes 76 species of Bryozoa from the shallow water down to 22 fathoms, in the region of the Tortugas, Florida. 8 are new to science and 40 are new to the Florida region.

No. 183. Papers from the Tortugas Laboratory of the Carnegie Institution of Washington. Vol. VI. Octavo, III+323 pages, 27 plates, 97 figures. Published 1914. Price $3.50.

This book contains the following papers, *not sold separately:*

Mayer, A. G.—The Effects of Temperature upon Tropical Marine Animals. 24 pages, 12 figs.

Mayer, A. G.—The Relation between the Degree of Concentration of the Electrolytes of Sea-Water and the Rate of Nerve-Conduction in *Cassiopea*. 30 pages, 13 figs.

Mayer, A. G.—The Law Governing the Loss of Weight in Starving *Cassiopea*. 28 pages, 1 plate, 21 figs.

Goldfarb, A. J.—Changes in Salinity and Their Effects upon the Regeneration of *Cassiopea xamachana*. 12 pages, 4 figs.

Goldfarb, A. J.—Regeneration in the Annelid Worm, *Amphinoma pacifica*, after removal of the Central Nervous System. 8 pages.

Goldfarb, A. J.—Experimentally Fused Larvæ of Echinoderms with Special Reference to their Skeletons. 20 pages, 15 figs.

McClendon, J. F.—Experiments on the Permeability of Cells. 8 pages, 3 figs.

Harvey, E. N.—The Relation between the Rate of Penetration of Marine Tissues of Alkali and the Change in Functional Activity induced by the Alkali. 16 pages, 1 fig.

Jacobs, M. H.—Physiological Studies on Certain Protozoan Parasites of *Diadema setosum*. 11 pages.

Dahlgren, Ulric.—Origin of the Electric Tissues of *Gymnarchus niloticus*. 36 pages, 9 plates, 9 figs.

Reinke, E. E.—The Development of the Apyrene Spermatozoa of *Strombus bituberculatus*. 46 pages, 7 plates.

Gudger, E. W.—The History of the Spotted Eagle Ray, *Aëtobatus narinari*, together with a Study of its External Structures. 91 pages, 10 plates, 19 figs.

Mayer states that tropical marine animals commonly live within 5° C. of their temperature of maximum activity and within 10° to 15° of their upper death temperature. Tropical forms are less resistant to temperature changes than are the animals of temperate seas. In tropical Scyphomedusæ depression of activity due to heat or cold appears to augment about as the square of the change in temperature above or below the optimum. Temperature is the most important factor in determining the ecological distribution of coral heads of various species over the reefs. High temperature probably causes death through asphyxiation.

In *Cassiopea* the rate of nerve conduction in diluted sea-water is determined by the concentration of the electrolytes sodium, potassium, and calcium, and not to changes in osmotic pressure. It makes practically no difference whether the sea-water be diluted with distilled water, 0.9 molecular dextrose, or 0.4 molecular magnesium chloride. The sodium and potassium cations are active stimulants for nerve conduction, but magnesium is practically negative, being neither a stimulant nor an active inhibitor of nerve conduction.

When starved *Cassiopea* loses weight according to the formula $y = w(1-a)^x$ where y is the weight at the end of x days, w is the weight when starving begins, and a is a fractional constant. Thus the loss in weight always remains proportional to the body-weight of the animal.

Dr. A. J. Goldfarb shows that in *Cassiopea* the maximum rate of regeneration is attained in diluted sea-water containing about 90 parts of sea-water to 10 parts of distilled water. Regeneration is normal again in about 85 per cent sea-water and declines in rate on further dilution. In concentrations of sea-water over and above normal, the rate of regeneration declines rapidly. Thus in *Cassiopea, Eudendrium,* and *Tubularia* the rate of regeneration is most rapid in diluted sea-water.

Dr. Goldfarb shows that the marine annelid *Amphinoma* can regenerate without the contact of or stimulation from the central nerve cord.

By treating the recently fertilized eggs of echini with sodium chloride in sea-water, Dr. Goldfarb succeeded in producing large numbers of fused larvæ. He made a detailed study of the causes of these fusions and the various fates of the fused larvæ, and the causes of their form equilibrium.

Dr. J. F. McClendon shows experimentally that the permeability of eggs to ions increases upon being fertilized.

Dr. E. Newton Harvey found that, as in the case of fresh-water organisms, the tissues of marine animals are penetrated more rapidly by weakly dissociated than by strongly dissociated alkalies.

Dr. Merkel H. Jacobs shows that there are remarkable differences in the resistance of the four common internal parasites of *Diadema,* and thus the similar habit of life in these four forms is not due to physiological similarity except in certain adaptive characters which are a *sine qua non* for life within the same host, such as ability to resist the digestive juices. Thus physiological characters of an organism are not merely the result of its environment, but may be as fundamental and characteristic as its morphological ones.

Professor Ulric Dahlgren finds that the electric tissues of *Gymnarchus* are developed by the differentiation of certain portions of its striated muscle-tissues during the larval period between the ninth and forty-second day of embryonic life. He traces this process, using serial sections, and gives a detailed account of the anatomy and histology of the electric organs, the development of which gives a strong clew to the probable development of the electric tissues in the other mormyrid fishes.

Dr. Edwin E. Reinke studied the origin of the dimorphic spermatozoa of *Strombus* and shows that the apyrene spermatozoa in their adult condition are devoid of nuclear material and may serve as nurse cells to the eupyrene spermatozoa or liberate some substance which may activate or sustain the eupyrene sperm. The eupyrene spermatozoa are the only ones concerned in the direct act of fertilization.

Professor E. W. Gudger presents a scholarly review of all literature relating to the spotted eagle ray, and gives an exhaustive account of its anatomy, habits, and distribution.

No. 211. Papers from the Department of Marine Biology of the Carnegie Institution of Washington. Vol. VII. Octavo, 128 pages, 9 plates, 19 text figures. Published 1915. Price $1.50.

This book contains the following papers, *not sold separately:*

Watson, J. B., and K. S. Lashley.—Homing and Related Activities of Birds. 75 pages, 7 plates, 7 figs.
Watson, J. B.—Studies on the Spectral Sensitivity of Birds. 19 pages, 2 figs.
Lashley, K. S.—The Acquisition of Skill in Archery. 14 pages, 2 plates, 9 figs.

The principal object of these investigations was to secure exact data on certain phases of distant orientation in birds. The field experiments were carried out upon the noddy and sooty terns at Bird Key, Tortugas, Florida. Several flights were made from distant points, *e.g.,* Cape Hatteras, Mobile, and Galveston. Returns were secured from places which lie north of the limits of distribution of these (tropical) birds and from Galveston Harbor, which is nearly 900 miles over unbroken water from Tortugas. This last flight establishes the fact that birds can home over territory which can offer no visual landmarks.

In order properly to control experiments on homing, it was necessary to go further into the instinctive and habit life of the terns than was done in our 1907

work (Publication 103). The principal activities studied were swimming; retention of habits of reacting to nest, mate, and nest locality, and methods of locating nest (proximate orientation).

A beginning was made upon the analysis of the sensory factors involved in homing. It was found that both chick and homing pigeon have limits of spectral sensitivity practically coextensive with man's. No support can thus be given to theories of homing which are based upon the use by the birds of infra-luminous light rays.

This volume also includes the report of an investigation on the acquisition of skill in archery. The special object of the experiment was to test the relative effects of shooting a large number of shots per day or a small number of shots (total amount of practice being the same). It was found that the group shooting the smallest number of shots per day made the greatest gain.

No. 212. Papers from the Department of Marine Biology of the Carnegie Institution of Washington. Vol. VIII. Octavo, 261 pages, 23 plates, 73 figures. Published 1915. Price $3.50.

This book contains the following papers, *not sold separately:*

Potts, F. A.—On the Rhizocephalan Genus *Thompsonia* and Its Relation to the Evolution of the Group. 32 pages, 2 plates, 12 figs.

Potts, F. A.—*Hapalocarcinus,* The Gall-forming Crab, with some Notes on the Related Genus *Cryptochirus.* 37 pages, 3 plates, 19 figs.

Potts, F. A.—The Fauna Associated with the Crinoids of a Tropical Coral Reef; With especial reference to its Colour Variations. 26 pages, 1 plate, 7 figs.

Clark, Hubert Lyman.—The Comatulids of Torres Straits, with Special Reference to Their Habits and Reactions. 29 pages.

Medes, Grace.—The Pluteus of *Laganum* sp. 16 pages, 22 figs.

Harvey, E. Newton.—The Permeability of Cells for Acids 14 pages.

Mayer, Alfred G.—Medusæ of the Philippines and of Torres Straits. 46 pages, 3 plates, 7 figs.

Bartsch, Paul.—Report on the Bahama Cerions planted on the Florida Keys. 10 pages, 8 plates.

Dahlgren, Ulric.—The Structure and Polarity of the Electric Motor Nerve-Cell in Torpedoes. 44 pages, 6 plates, 6 figs.

Lieutenant Frank A. Potts, M.A., describes the histology, development, and relationships of the highly specialized Rhizocephalan genus *Thompsonia* from Torres Straits, Australia.

In another article the same author gives the results of his exhaustive study of the habits of the gall-forming crab *Hapalocarcinus,* which forms so-called "galls" among the branches of the coral *Pocillopora.* A detailed account of the formation of these galls is given together with the first description of the minute male crab and of another coral-infesting crab *Cryptochirus,* and other semi-parasitic or commensal forms. The author determines their various hosts and draws conclusions respecting their affinities.

In a third paper Mr. Potts describes the habits and reactions of the crustacea, echinoderms, worms, and mollusks which are associated with the Crinoids of the Murray Island reefs, and shows that while in general the color of these animals is similar to that of their hosts, there are some striking exceptions, so that protective coloration was not always realized.

Dr. Hubert Lyman Clark describes 22 species of Comatulids from Torres Straits, 7 of which are believed to be new to science. Some of these forms are very sluggish, while others are quite active. They are chiefly vegetable feeders, but also devour protozoana; all are negatively phototactic, and are sensitive to changes in temperature of only 2° C.

Miss Grace Medes gives a detailed description of the structure and anatomy of the pluteus larvæ of a *Laganum,* which were collected by Professor David H. Tennent in Torres Straits. The larva is bilaterally symmetrical even at a late stage. Early growth is very rapid, the larval skeleton is complex. The amniotic cavity is formed from a central invagination, and the interocœle and hydrocœle show interesting peculiarities.

Dr. E. Newton Harvey presents a notable study of the rates at which various acids penetrate the living cells of a holothurian *Stichopus ananas,* the pigment of which is normally purple but becomes red when the cell is penetrated by an acid. There appears to be some fat-like body on the cell surface. There is no relation

between the degree of dissociation of an acid and its rate of penetration, but the toxic acids penetrate most readily irrespective of their strength. Acids and alkalies which are soluble in fatty substances penetrate living cells readily while those which are insoluble are poor penetrators. Acids penetrate more rapidly than alkalies.

Dr. Alfred G. Mayer describes 31 species of Scyphomedusæ obtained by the U. S. Fish Commission steamer *Albatross* in the Philippine Islands, 9 of which were apparently new to science. He also describes 6 Hydromedusæ from the Murray Islands, Torres Straits, and speaks of the physiology, reactions, and habits of the Scyphomedusæ, and of the poverty of the region of the Great Barrier Reef of Australia in comparison with that of the Philippines.

Dr. Paul Bartsch gives an account of an extensive series of experiments in transplanting *Cerions* from Andros Island, Bahamas, to the Florida Keys, the new colonies ranging from near Miami to the Tortugas. The first generation of these snails born in Florida differs from their Bahama-born parents, but the cause of this sudden departure remains to be determined.

Professor Ulric Dahlgren describes the structure and polarity of the electric motor nerve-cell in various species of *Torpedo*. He concludes that the plasmosome is the heaviest body in the nucleus, and is probably of greater specific weight than any other nuclear constituent, with the possible exception of the karyosomes. Thus it is due to gravity that in adult fish the plasmosomes came to occupy a ventral position within the nucleus. Very strong electric currents may move this plasmosome but weak currents do not affect it, and thus the author dissents from Magini's theory that the electric discharge is coördinated with a ventral-ward movement of the plasmosome.

No. 213. Papers from the Department of Marine Biology of the Carnegie Institution of Washington. Vol. IX. Quarto. In press.

This book contains the following papers, *not sold separately:*

Mayer, Alfred G.—Ecology of the Murray Island Coral Reef.
Cary, L. R.—The Gorgonaceæ as a Factor in Coral Reef Formation.
Vaughan, Thomas Wayland.—The Shoal-water Coral Faunas of Murray Island, Australia, Cocos-Keeling Islands, and Fanning Island.

Mayer finds temperature to be a very important factor in determining the habitat and range of reef corals. High temperature asphyxiates the corals. Thus the shore-flat corals, which must survive being buried under mud, are usually correspondingly resistant to heat; while the off-shore corals are easily killed by heat or by silt. The corals struggle among themselves and the fittest survives, but no species of coral has become improved as a result of the struggle. More kinds of corals live in agitated water near the breakers than anywhere else upon the reef flat, but coral heads are most numerous about 200 feet inward from the inner wash of the breakers. Four of the 24 genera of corals, *Porites, Pocillopora, Seriatopora,* and *Acropora*, constitute 91 per cent of the number of coral heads. The author makes the first quantitative, intensive, ecological study of a coral reef yet attempted.

Dr. L. R. Cary finds that at Tortugas, Florida, the Gorgonaceæ contribute more limestone to the reefs than do the stony corals.

No. 214. Clark, H. L. *The Echinoderms of Torres Strait.* (Paper from the Department of Marine Biology of the Carnegie Institution of Washington.) Quarto. In press.

No. 177. Loeb, Leo, in collaboration with Carl L. Alsberg, Elizabeth Cooke, Ellen P. Corson-White, M. S. Fleisher, Henry Fox, T. S. Githens, Samuel Leopold, M. K. Meyers, M. E. Rehfuss, D. Rivas, and Lucius Tuttle. *The Venom of Heloderma.* Octavo, vi+244 pages, 38 figures. Published 1913. Price $1.50.

This volume contains a collection of papers dealing with the morphology of the venom gland, the physical and chemical properties of the venom, the action of the venom on vertebrate and invertebrate animals, as well as on certain cells and organs *in vitro*. In an introduction a summary of the results of these investigations is given with special reference to the properties of snake venoms, and problems for further research are suggested.

No. 12. Noguchi, Hideyo. *The Action of Snake Venom upon Cold-blooded Animals.* Octavo, 16 pages. (Embodied in Publication No. 111.) Published 1904. Price $0.25.

No. 111. Noguchi, Hideyo. *Snake Venoms: An Investigation of Venomous Snakes with Special Reference to the Phenomena of their Venoms.* Octavo, xvii+315 pages, 33 plates, 16 text figures. Published 1909. In cloth. Price $10.50.

Although this volume refers more especially to the phenomena of snake venom, it covers much broader ground. The first fifty pages are devoted to a descriptive and systematic morphological and a distributional account of the poisonous snakes of the world, over 300 forms being enumerated, followed by a description of the poison apparatus. In a short chapter on the phylogeny of poisonous snakes, the author states that the poison gland was probably the first of the specialized structures to appear, and that the elaborate, erectile, grooved fangs were of later development. The poison gland "is equivalent to, if not identical with, the parotid of the mammalia?" The remainder of the work is given up to a consideration of the venom itself. There are chapters on its physical and chemical properties; symptoms of venom poisoning in man and in lower animals; and on the organism as a whole and upon specific organs and tissues.

There follow chapters on artificial and natural immunity, with a technical discussion of antivenins. The final chapter, "Treatment of Snake Bites," contains a careful review of the various so-called antidotes with a scientific testing of their value. The monograph ends with a bibliography of about 400 titles and an index.

No. 159. Howard, L. O., Harrison G. Dyar, and Frederick Knab. *The Mosquitoes of North and Central America and the West Indies.* In 4 volumes. Octavo. Price $10.00 per set of 4 volumes.

Vol. 1. A General Consideration of Mosquitoes, their Habits and their Relations to the Human Species. vii+520 pages, 14 plates, 6 text figures. Published 1912.
Vol. 2. x pages, 150 plates. Published 1912.
Vol. 3. Systematic Description, Part I. Pages vi+523. Published 1915.
Vol. 4. Systematic Description, Part II. In press.

This report contains a full account of the mosquitoes of North America, from the Isthmus of Panama northward, including the West Indies and Trinidad, but exclusive of the Arctic regions. Tables are given for determining the genera and species, both as larvæ and adults, with full accounts of each species, with synonymy and bibliography, and their life-histories and habits so far as known, illustrated by numerous drawings of male genitalia, larvæ and larval details, eggs, and pupæ. The introductory first volume gives a general consideration of the anatomy and of the different stages of mosquitoes, their metamorphosis and habits; also an outline of the most recent results in the study of mosquitoes as carriers of disease, accounts

of other relations of these insects to man, and a full general discussion of the subject. All the methods of control of the noxious species are discussed, especially in their relations to the individual species concerned in the transfer of diseases, of which the most important are yellow fever and malaria.

No. 18. Morse, Albert P. *Researches on North American Acridiidæ.* Octavo, 56 pages, 8 plates. Published 1904. Price $0.50.

The investigation on which this report is made was directed toward the acquisition of facts of faunal, biological, and morphological value concerning the acridian fauna of the southeastern United States (a portion of the country hitherto largely unexplored) with reference to this group of insects. A general account of the investigation is given, together with a statement of the results secured; the data on which the generalized statements are based; an annotated list of the species taken, with locality, habitat, and the date of capture; brief notes on the geographical and zonal distribution of the genera of North American Acridiidæ; and contributions to locust biology in the shape of a classification of locust habitats and societies and an explanation of brachypterism in Orthoptera.

No. 68. Morse, Albert P. *Further Researches on North American Acridiidæ.* Octavo, 54 pages, 10 plates, 1 text figure. Published 1907. Price $0.50.

The above report is based upon data obtained during the second field trip in the summer of 1905. The purpose of the latter trip, like that of the former, was to secure general information regarding North American locust fauna and its ecology over a wide extent of little-studied territory. A large amount of material and biological data were secured, together with several previously undescribed forms.

No. 197. Wright, Albert Hazen. *Life Histories of North American Anura: The Anura of Ithaca, New York.* Octavo, 98 pages, 21 plates. Published 1914. Price $2.00.

This work treats of eight of the common species of the eastern United States and considers their general habits, the temperature and time of first appearance in the spring, the mating and egg-laying phenomena, the characters of the eggs and their hatching periods, the characters of the tadpoles and their larval periods, the transformation sizes and seasons, and finally the autumn disappearance. The plates and the text figures illustrate the amplexation of each form, the egg masses, the individual eggs, the tadpoles, the transformed examples, and other interesting phases of their life histories.

For other works relating to Zoology, see Nos. 23, 25, 48, 49, 52, 64, 67, 70, **95,** 101, 104, 114, 121, 122, 142, 143, 144, and 149, on pages 85-96.

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